POWER

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NOTHING on this footstool stands still; in fact, the stool itself does not stand still.

Everything either goes ahead—progresses—or goes back—retrogresses.

The child, progressing from total helplessness, creeps, then walks erect.

The orphaned egg retrogresses from a sweet and wholesome article of diet at first, through successive stages of increasing strength, until it becomes at last a loud and boisterous outrager of the noses of all who are not afflicted with a cold in the head.

Everywhere, in everything and everybody, is progress or its opposite; there is no standing still.

There may be an apparent standing still, but close investigation will show that in reality there is either progress or retrogression. An idle steam engine is not actually standing still except in the dynamic sense of the word; it is daily growing more obsolete and, hence, its selling value is continually decreasing.

Wine lying idle in the cask is idle only in the physical sense. If left undisturbed long enough, it will become so rich and mellow that its bibbers will declare it of immortal vintage.

In all science progress is the rule, because each new pioneer takes up his work at the point where his predecessors left off. If this were not so, civilization could not be.

Each generation would have to fabricate its own language, develop its own arts, industries, etc.

Because of the continually accelerating progress in scientific knowledge, we are able to cross the ocean in that marvel of engineering effort, the steamship "Olympic," within a hundred and four years after Fulton succeeded in making the "Clermont" paddle a wheezing four miles an hour on the Hudson river.

The progress in steam engineering during the last few score of years has been both rapid and wonderful.

The truth of this is very forcefully illustrated by two articles in this issue. One is descriptive of Philadelphia's veteran steam engine and the other of the New York Edison Company's newest turbine generating unit. It is a big, big jump from a 122-horsepower machine to one whose normal capacity is placed at 20,000 kilowatts or some 26,666 horsepower. Yet this jump has been made within the space of sixty-four years, a period less than man's allotted span of life.

The thoughtful perusal of these two articles should be as good as a sermon based on the parable of the ten pieces of money.

Surely, many men have increased their one pound's worth of knowledge and ability to five and ten pounds' worth ere such impressive strides were finally brought within the limits of accomplishment.

Witherbee-Sherman's New Station

By Guy C. Stoltz*
and Samuel Shapira†

A modern plant supplying electrical energy to operate magnetite mines in the neighborhood of Mineville, N. Y. A large reciprocating engine and mixed pressure turbine with a combined maximum output of 1500 kilowatts drive the generating equipment.

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Witherbee, Sherman & Co.'s central electric-power plant is situated in the western part of Mineville, N. Y., and its power, together with that generated at the Port Henry plant, described in a previous article, and that of two hydro-electric stations nearby, is used to operate the magnetite mines of the neighborhood. The building is of red brick with steel trusses and corrugated-iron roof. The main structure is rectangular, 96x55 feet and 30 feet high, with an additional boiler-room extension 30x55 feet. All the floors are of concrete and the building is practically fireproof. A concrete transformer house, 28x18 feet, joins the power house. The engine-room floor is 14 feet above the boiler-room floor and 9 feet above the engine-room basement.

Boiler Equipment

The boiler room is 45x81 feet, and contains three Geary water-tube boilers and one Babcock & Wilcox boiler. Each Geary boiler is rated at 250 horsepower and contains one hundred and sixty 3½-inch tubes 14 feet long, with water drums 42 inches by 18 feet. The grate surface of each boiler is 55 square feet. The Babcock & Wilcox boiler is rated at 400 horsepower and has 4000 square feet of heating surface which consists of three steam and water drums, 36 inches by 23⅓ feet, placed above and connected to a set of 21 sections of tubes, each section consisting of nine 4-inch tubes 18 feet long. The grate surface of this boiler is 90 square feet. Each of these four sets of boilers is provided with McClave sectional, top-shaking grates, fitted with twin levers for divided cutoff movement. The boilers are also provided with Wing turbine blowers for forced draft. The Babcock & Wilcox boiler is equipped with two 20-inch blowers, and the Geary boilers each have one 20-inch blower, all side installed. A Davis regulator is used in connection with the Wing blowers.

The feed water for the boilers is supplied by a 10x6x10-inch Knowles pump of the outside-packed plunger type. A second feed-water pump, a 10x6x12-inch Dean, outside-packed, plunger type, is held in reserve. These pumps are placed ene at each end of the boiler room. Boiler water is obtained from a pond fed by the Dalton reservoir, 3 miles north of Mineville. The feed water is heated by a Cochrane, open-type, feed-water heater, placed directly back of the boilers. Two pumps supply water to the Cochrane heater; one is a Knowles 7x5-inch and the other an Alberger 2½-inch volute pump, run by a 5-horsepower motor, and taking water from the condenser in the engine room.

Saturated steam is led from the boilers through 8-inch extra-heavy U-pipes to the steam chests of the Nordberg Corliss engine. A 6-inch extra-heavy pipe line extends to the steam chest of the low-pressure turbine. All saturated-steam pipe lines are covered with asbestos fire-felt covering of standard thickness.

Smoke goes to the stack through a 5½x7-foot steel breeching. The unlined steel stack, which is outside the building, is 7 feet in diameter and 110 feet high, is self-supporting and rests upon a solid-concrete foundation 17x17 feet and 9 feet high.

The boilers are hand fired with No. 2 buckwheat anthracite coal, which is delivered to the boiler room by an overhead track supported by concrete posts 8 feet above the boiler-room floor. Coal is received from the Lake Champlain & Moriah Railroad over a timber trestle 348 feet long, which has an open concrete-storage bin of 2500 tons capacity underneath. Ashes are delivered by the McClave-Brooks system of scrapers to an outside pit where they are loaded by bucket elevator to a concrete storage bin. From the bin the ashes are drawn off in wagons and used for road building.

Turbine Generating Equipment

The engine room is 44½x52 feet and all the engine auxiliaries, except the exciter and switchboard, are placed below the engine-room floor. The generating apparatus consists of a Nordberg horizontal, cross-compound, condensing engine with cylinders 23 and 46 inches and 48 inches stroke, and a horizontal, mixed-pressure turbine. The Nordberg engine develops 1000 horsepower at 150 pounds pressure and 100 revolutions per minute. It is direct-connected to a flywheel alternator rated at 750 kilowatts, 94 revolutions per minute, 3300 volts. An exciter is belted to the alternator shaft.

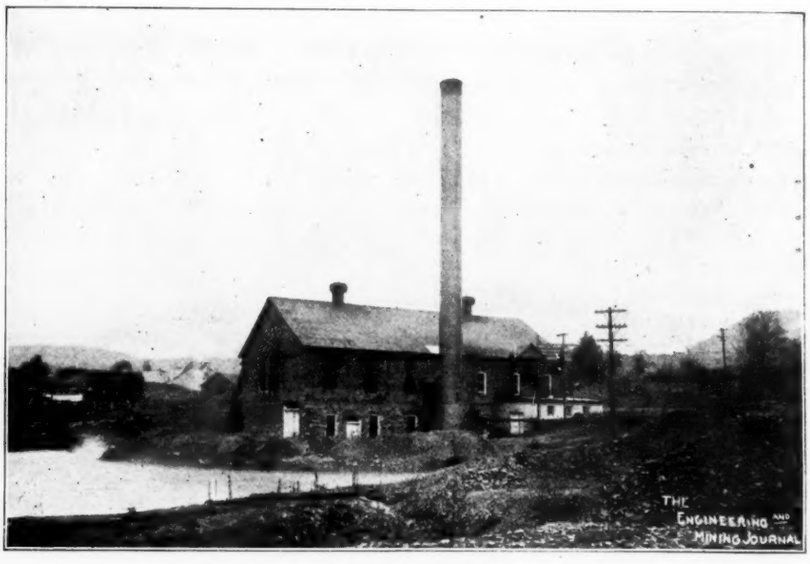


Fig. 1. Exterior View of Mineville Plant

The low-pressure turbine is of the horizontal Curtis type, designed to run condensing, and rated at 750 kilowatts. It is run on the exhaust steam from the Nordberg engine. When operated on live steam at full rated load with not more than 2 inches absolute back pressure in the exhaust chamber of the turbine, and with a gage pressure of 150 pounds at the throttle, the consumption of dry steam does not exceed 26.5 pounds per kilowatt-hour. The turbine develops 520 kilowatts on the exhaust steam from the engine, when the latter is carrying a load of 650 kilowatts, giving an output from the combined units of 1170 kilo-

watts at a water rate of 18.05 pounds per kilowatt-hour at the switchboard.

If necessary, the output of the two units can be increased to 1500 kilowatts by admitting additional high-pressure steam into the turbine. In case of accident to the engine, it can be shut down and the turbine will then carry 750 kilo-

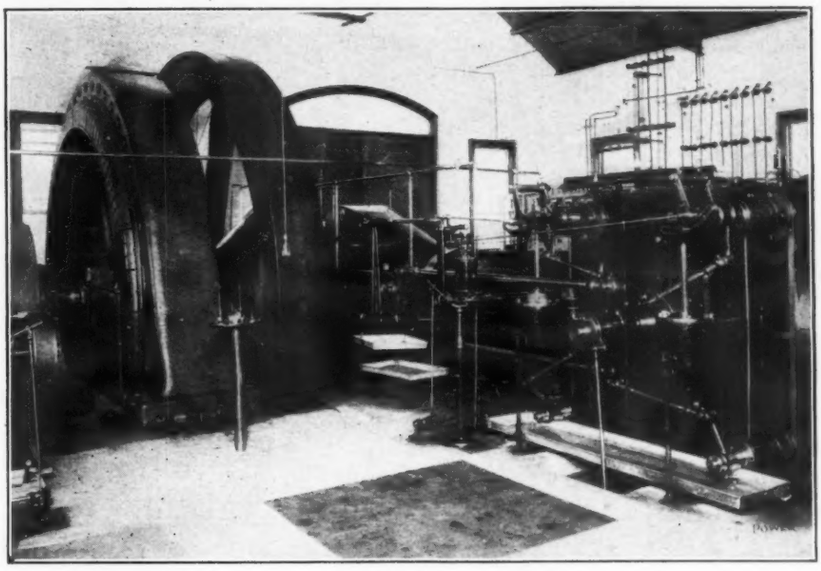


FIG. 2. MAIN GENERATING UNIT OF 1000 HORSEPOWER CAPACITY

watts on live steam, with a consumption of 26.5 pounds per kilowatt-hour, which is approximately the same as the steam consumption of the Nordberg engine. Under ordinary conditions, however, the turbine operates on the exhaust steam alone from the engine.

The exciter used in connection with the turbine consists of a 50-horsepower induction motor and a generator rated at 35 kilowatts. An equalizer rheostat is used between the field of this exciter and the exciter used with the engine-driven alternator.

The Curtis low-pressure turbine rests upon a reinforced-concrete platform 18 x8x1 foot, supported by six reinforced-concrete columns 12 inches square and 13 feet high. The reinforcement for the platform consists of 10-inch I-beams and 8-inch channels, the reinforcement for each column being six strands of 1½-inch wire rope. The space beneath the platform is used for the turbine auxiliaries, consisting of an Alberger condenser having a condensing surface of 4500 square feet; an 8 and 20 by 12-inch dry-vacuum pump, and a 12-inch standard volute pump having a 14-inch suction. The condensed steam is delivered by an Alberger 2½-inch volute pump to the feed-water heater in the boiler room.

HYDROELECTRIC POWER STATIONS

The two plants here described are owned by D. F. Payne, of Wadham Mills, N. Y., and furnish power for adjoining magnetite mines. The Kingdom plant is operated by the flow in Beaver brook, which has its source at Lincoln pond, six miles from Mineville, at 1150 feet elevation. The pond is supplied by springs, but principally by the drainage of approximately 17 square miles of mountainous country.

The power house, a wooden structure, is situated one miles from the pond. A concrete dam above the plant delivers the water under a head of 316 feet through a

FIG. 3. MIXED-PRESSURE TURBO-GENERATOR

32-inch steel penstock to a Pelton wheel running at 500 revolutions per minute, direct connected to a 375-kilowatt, 6600-volt alternator. An 11-kilowatt, 125-volt exciter is belted to a pulley on the main-generator shaft.

Current for power at 6600 volts is transmitted seven miles to the central plant at Mineville, where three single-phase, oil-cooled transformers step the voltage down to 3300.

The Wadhams plant is situated on the Black river, six miles east of the Kingdom plant. The overflow from Kingdom dam and the discharge from the Pelton wheel, together with the natural drainage running to the river, are stored at this plant by a concrete dam. The power house is equipped with a 300-kilowatt, 6600-volt alternator, belt connected to a turbine operating under a 48-foot head. The penstock from the dam is 54 inches diameter and 350 feet long. Excitation for the generator is provided by a 7½-kilowatt generator belted to the main shaft.

The current at 6600 volts is transmitted nine miles to the Cook shaft station at the Smith mine, two miles north of Mineville proper. Here the voltage is stepped down to 3300 by oil-cooled transformers connected in delta. From the transformers the power is delivered to the central plant at Mineville.

POWER DISTRIBUTION

The transmission lines from the Port Henry plant, carrying 2300 kilowatts at 6600 volts; the lines from the central plant, carrying 2175 kilowatts at 3300 volts; and the 675 kilowatts from the two hydroelectric plants have their busbars so connected at the A & B distributing station that any one of the plants may be operated on any of the feeder lines, or they may all be run in parallel, the voltage being maintained by means of a regulator on each generator.

At the main distribution station the lines are connected through automatic overload oil switches to the 3300-volt distributing busbars of an 11-panel switchboard, of which there are two panels for 402-horsepower synchronous motors

driving two 2500-cubic foot compressors; two for 200-horsepower motors driving two 1200-cubic foot compressors; two for the lighting of Witherbee and Mineville; one panel for a 12-horsepower motor driving one vertical triplex pump in A shaft; one for a 30-horsepower motor driving one horizontal triplex pump in B shaft; one for a 300-horsepower motor driving a Wellman-Seaver-Morgan four-drum hoist; one for motor drives at concentrating mill No. 1; and one for motor drives at concentrating mill No. 3. All power from the switchboard at the main station is delivered at 440 volts, except to the lines for the synchronous motors, and those for mills Nos. 1 and 3, which receive power at 3300 volts. At the mills the current is stepped down to 440 volts.

One of the synchronous motors is belt connected to a 2500-cubic foot Nordberg 30 and 44 by 48-inch two-stage air compressor. The second motor drives in like manner an Ingersoll-Rand two-stage compressor, 18¼ and 30¼ by 27 inches. The synchronous motors have recently replaced the induction type in order to realize a higher power factor and to obtain better regulation. These motors are operated with an input of 360 kilovolt-amperes and 80 per cent. leading power factor. Both motors are rated at 400 horsepower at 3300 volts, and are excited by direct-connected exciters. They are started as induction motors at 1650 volts, and when the speed is near synchronism they are connected directly to the 3300-volt lines.

Two 1200-cubic foot Ingersoll-Rand 16¼ and 18¼ by 25-inch two-stage compressors are belt connected to two 200-horsepower, 440-volt induction motors. A Wellman-Seaver-Morgan four-drum geared hoist for A and B shafts of the Harmony mines is driven by a 300-horsepower induction motor. Three oil-cooled, single-phase transformers are provided for the smaller compressors, three-phase, oil-cooled for the pumps, and one three-phase, air-cooled for the hoisting equipment.

Transmission System

The main transmission lines leading from the central plant to A & B distribution station are tapped by sublines which lead to mill No. 2, where the 3300-volt current is transformed to 440 volts and distributed through a three-panel switchboard to the various motor drives. A second set of branch lines carries power to the Joker & Bonanza hoisting house, delivering it to busbars from which it is distributed to the several transformers through a panel switchboard and thence to a two-drum hoist geared to a 500-horsepower induction motor, and also to a 1200-cubic foot Ingersoll-Rand compressor, belt driven by a 200-horsepower induction motor. A third set of sublines carries 3300 volts to the Barton Hill mines, through transformers reducing 3300 to 400 volts, and delivering to an electric tram, an auxiliary hoist and a 75-horsepower induction motor driving an Ingersoll-Rand two-stage, 650-cubic foot compressor. A fourth set of lines carries the usual voltage to the Cook shaft hoist station at the Smith mine, where, after being transformed, it is delivered to two 75-horsepower induction motors driving two Ingersoll-Rand 650-cubic foot compressors, to one motor driving a 100-horsepower, Wellman-Seaver-Morgan two-drum hoist, and lastly to a 30-horsepower motor driving a vertical triplex pump near the sump at the foot of the Cook shaft.

The compressor installation at the A & B distributing station, together with the auxiliary compressors at the other hoist houses, consumes the greater part of the power generated by the four plants. The total air equipment, which includes several emergency, steam-driven compressors, can deliver about 12,000 cubic feet of free air per minute at 85 pounds gage pressure at the machines.

An electric-locomotive haulage system is installed in the Joker & Bonanza mine, the tram cars being dumped at the shaft pockets by electrically operated tipples.

Cost of Power

In 1910, the average cost of power from the four generating stations per kilowatt-hour was $0.009 for operating only, or $0.013 for a total. The cost per ton of ore mined was $0.164 for operating only, or $0.191, including fixed charges. The consumption of power averaged 13.8 kilowatt-hours per ton of ore mined.

The distribution of load in kilowatt-hours during 1910 was: Compressors, 4,797,918; mills, 1,967,776; hoists, 755,599; pumps, 207,031; miscellaneous, 475,867; commercial power, 575,579; total, 8,779,800 kilowatt-hours.

Comparison of the power costs for compressing and hoisting at the Harmony electric plant and at the Joker & Bonanza steam plant, showed a saving of nearly 3 cents per ton of ore mined in favor of the former. Costs for power at the electric plant totaled $0.0451 per ton mined; at the steam plant the items were:

HOISTING

Coal	$0.0507
Labor	0.0074
Supplies and repairs	0.0053

COMPRESSING

Coal	0.0062
Labor	0.0019
Supplies and repairs	0.0024
Total	$0.0739

The steam plant at the Joker & Bonanza mine is now being replaced by an electric hoist and electric-driven compressors.

The Chief's Pay

By H. M. Phillips

The A. & B. plant was experiencing one of its protracted shutdowns. In order to avoid total disorganization of its working force a favored few were allowed to remain on the payroll and do a full day's work, on repairs, etc., for half pay, their regular pay to be resumed when the plant should again be in active operation. As there was no other chance for employment in the vicinity, this liberal offer was accepted with more or less enthusiasm, by those who did not care to move; among the fortunates was the chief engineer of the plant. As the time for starting up approached, extensive alterations and repairs were in order, many new men were taken on and, of course, these had to be paid at, or near, the rates prevailing in other plants, although the old hands, much to their dissatisfaction, still remained on half pay. One of the new members was a machine-shop foreman who, upon the death of the old chief, applied for and obtained a temporary appointment as chief engineer, pending a definite arrangement for filling the position. While acting in this capacity he had an interesting experience with an engine governor which furnished considerable amusement but probably prevented his receiving the permanent appointment. At the end of two weeks he returned to the machine shop.

When the monthly payday came around, a very indignant and aggressive foreman appeared before the paymaster; the conversation that ensued was along the following lines:

Foreman: See here, mister; you have made a mistake in my pay and I want it made right.

Paymaster: Why, certainly, if there is a mistake we are here to correct it; let me see your pay slip, please. What is the trouble? It looks all right to me.

Foreman: It does, does it? Well, it looks a good ways from right to me; just you see if you haven't forgotten something.

Paymaster: Come to the point, please, and tell me just what you think is wrong; this slip is the same as last month's and you made no complaint then.

Foreman: Do you happen to know that for two weeks of this month I was acting chief engineer of this plant, and that Mr. G., the vice-president, told me that while I was acting chief I would receive the chief's pay?

Paymaster: Come to think of it, I did hear a good deal about the acting chief engineer, but the vice-president said nothing to me about the pay; hence I have no authority to change your regular rate. He is away now, but will be back in a week or 10 days and if you wish I will speak to him about it.

Foreman: I want the money now. Mr. G. told me, and I reckon that what he says goes around this plant. You will fix that up, and do it quick, or you will wish you had after I see him.

Paymaster: I don't want to get into any trouble with Mr. G.—he is a friend of yours, I hear—and if he told you so I suppose it must be all right.

Foreman: He did tell me, I have told you before, and it is all right; so get a move on.

Paymaster: You know I have no real authority in the matter, but still if Mr. G. said so—

Foreman: I tell you he did.

Paymaster: It must be all right.

Foreman: It is all right.

Paymaster: All right, then; the chief engineer was getting 25 cents a day less than you are.

That ended the argument. Some readers may be inclined to agree with the foreman's concluding remarks—he did not know about the half-pay arrangement—"A man that would do the work for that pay ought to die."

Surface Combustion in a Boiler

William A. Bone, D.Sc., F.R.S., professor of applied chemistry at the University of Leeds, England, has been visiting the United States for the purpose of repeating before the American Gas Institute at St. Louis and at the Chemists Club, New York, his lecture upon "Surface Combustion," which attracted so much attention when presented to the Royal Society this spring.

A combustible mixture of gas and air, introduced directly into the tubes filled with broken fireclay, burns without flame and evaporates 21 pounds of water per square foot of heating surface. This is about seven times the usual amount and gives an efficiency of over 93 per cent.

It has been known for some time that the gases of a combustible mixture would unite below the temperature of ignition. Hydrogen and oxygen will unite without any sign of flame at about 500 degrees Centigrade (932 Fahrenheit) while the ignition point at which the more rapid combination generally known as combustion occurs is 50 degrees Centigrade or 90 Fahrenheit degrees higher. The rate of combination below the ignition point is slow, but can be greatly increased when certain materials, such as porous porcelain, fireclay and some of the metals are brought within the mass of the combustible mixture. An example of this is the use of platinum for lighting a jet of gas.

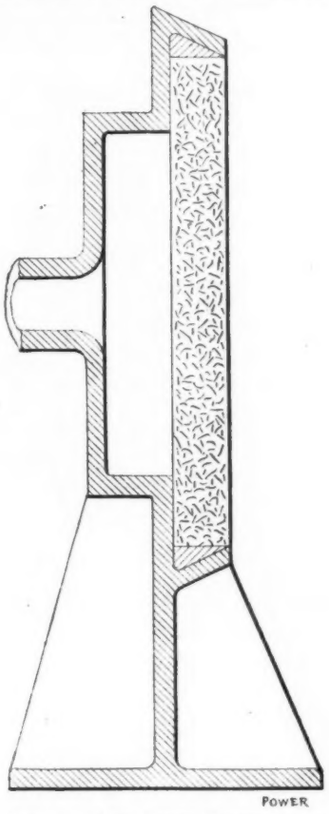


FIG. 1. THE FIRST EXPERIMENT

This stimulation is not confined to the subignition temperature, but it has been found that the presence of incandescent bodies in a burning mixture increases the activity of the combustion; the combination of its constituent gases takes place more quickly than when it is not there, more heat is generated per unit of time and flame is absent.

Perhaps the best idea of the subject may be gained by a glance at Professor Bone's first experiment. A frame, Fig. 1, surrounding a slab of porous refractory material is closed at the back so as to form a chamber into which a mixture of gas and air in the proportions necessary for combustion, or containing an excess of not over 1 per cent. of air, is introduced under a pressure of between ⅛ and ¼ of an inch of water. The escaping gas is ignited upon the face of the slab, which soon becomes incandescent. The flame disappears entirely, and the combustion progresses at the surface of the tile or at a depth of not exceeding ⅛ inch. One can put his hand upon the casing at the back and Professor Bone says he could with equal immunity put it upon the back of the porous slab if that were accessible.

Such a slab in an inverted position was held over a dish of silicate of soda in solution, showing the rapid evaporation and the solidification of the water glass by downward radiation onto the surface of the liquid. A smaller plate was immersed, while the combustion was in active operation, in a glass jar of carbonic acid gas without any diminution of the incandescence of its surface, showing that the combustion is independent of the atmosphere in which it takes place. Muffles are made by burning gas around the retort in a conglomerate mass of finely divided refractory material.

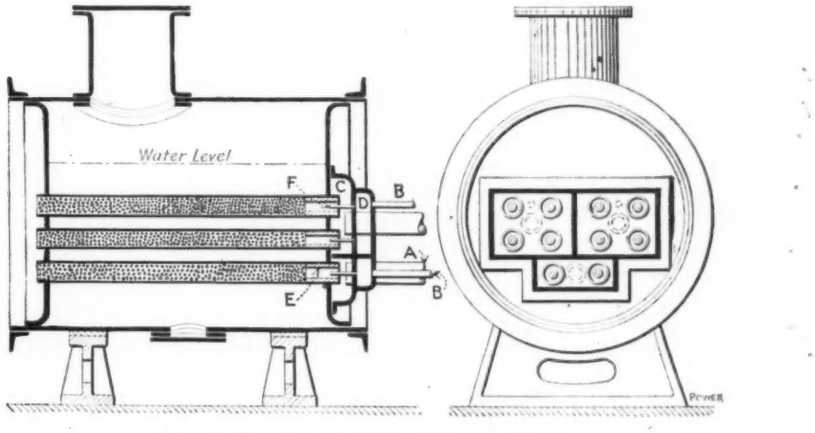


FIG. 2. SECTION AND END VIEW OF BOILER

The most interesting application shown from the point of view of the power-plant engineer was to a boiler. From the report of *London Engineering* of the original lecture is reproduced in Fig. 2 the section of such a boiler having 10

tubes, 3 inches in internal diameter. Each of these has a bush *E* of fireclay and is filled for the rest of its length with finely broken refractory material. At one end these tubes are covered by a casing which, as is shown in the end view, is divided into three compartments, so that either 2, 4, 6, 8 or 10 of the tubes may be used at a time. The casing is further divided as shown in the longitudinal view into two chambers, *C* and *D*.

When starting up, air alone is admitted to the chamber *C* by means of the tubes *A* and gas alone to the chamber *D*, by means of the tubes *B*. The small tubes *F* convey the gas to the centers of the fireclay bushes in the several tubes and it is ignited as it issues from the left-hand or free ends of the boiler tubes, and the gas and air supply adjusted until the flame strikes back and combustion proceeds in the bed of fireclay. When the mass has become incandescent the gas supply to chamber *D* is shut off and through the pipes *A* a combustible mixture of gas and air is admitted. The separate admission is necessary at first to prevent the backfiring of an explosive mixture during the starting-up process. After combustion is established the combustible mixture can be introduced direct if admitted at a velocity greater than that of flame propagation so that the fire cannot run backward into it.

The gas burns without flame in the front end of the tube, the incandescent mass being in direct contact with the heating surface. When such a surface has to absorb heat from a current of hot extinguished gas, as from the products of combustion in an ordinary boiler tube, the gas in immediate contact with the tube becomes chilled and this film of cool gas prevents the contact of the hotter gases with the heating surface. Being a very poor conductor, it seriously impedes the transfer of heat from the gases to the water. Such a film is, however, entirely transparent to radiant heat, and the heat from the glowing mass is taken up by the water with great rapidity. Observation shows that about 65 per cent. of the evaporation occurs upon the first foot of the tube length, about 25 per cent. upon the second foot and only the remaining 10 per cent. upon the last foot.

The evaporation in regular working is over 20 pounds per square foot of heating surface, and this can be increased 50 per cent. with a falling off in efficiency of only 5 or 6 per cent. The gases leave the tubes at a temperature not much over a hundred degrees Fahrenheit above that of the steam, and are further reduced by means of an economizer. The combined efficiency of the boiler and economizer is over 93.4. Some test figures follow:

Date, December 8, 1910		
Pressure of mixture entering boiler tubes	17.3 in. H_2O	
Pressure products entering feed-water heater	2.0 in. H_2O	
Pressure steam	100 lb. gage	
Corresponding temperature	168 C.	334 F.
Temp. gases leaving boiler tubes	230	446
Temp. gases leaving heater	95	203
Temp. water entering heater	5.5	41.9
Temp. water leaving heater	58	136.4
Evaporation per square foot heating surface	21.6 lb.	

HEAT BALANCE

Gas per pound water at 32° and atmospheric pressure	996 cu.ft.
Net calorific value	562 B.t.u
Heat supplied to boiler per hour	559,800 B.t.u.
Water evaporated per hour	450.3 lb.
Water evaporated from and at 212° per hour	550 lb.
Heat transferred to water per hour	527,800 B.t.u.

$$\text{Ratio } \frac{527,800}{559,800} = 0.943$$

Cost System for Power Plant Operation

By Charles W. Gill

By means of a card system a complete record is kept of all labor and material for both construction and repair work. In addition to this, weekly reports are made concerning the condition of all apparatus.

From time to time articles have appeared in the technical press upon keeping shop costs, but these articles have dealt almost exclusively with the cost of production of staple machines, articles, etc., explaining the various systems devised to show the true profit or loss and to furnish a foundation on which to estimate for the future. These systems are very effective and often result in a decided saving.

The following, however, describes a system devised by the writer for the power and repair plant of Butler Brothers, Jersey City, to ascertain the cost of upkeep of the various parts of the equipment.

Some system in all large plants is necessary to keep a proper account of this cost and the relation between maintenance and repair, without involving much clerical labor. The starting point of this system is with the "Requisition for Construction or Repairs," shown in Fig. 1. These cards are filled out by the foreman of the different departments as to the work required. They are then sent to the writer, who gives the job a number; if new work, an even number, and if repairs, an uneven number. In case of new work the card is O. K.'d by the superintendent. The job is then assigned to the proper mechanic and when the work is completed it is O. K.'d by the workman and by the foreman in charge of the department in which work has been done.

On the reverse side of this card is space for the cost of labor and material which is entered each day from the workmen's time cards. This cost sheet is shown in Fig. 2.

The time card is filled out by the workman in the space or spaces according to the number of departments he has worked in, he inserting the letter of the department in the first column. He then gives

NEW WORK NO. REPAIR NO.

REQUISITION FOR CONSTRUCTION OR REPAIR WORK

Department Floor Date

Description

Signed

New Work Authorised

Date completed

Workman's O. K. O. K. of Dept. Foreman

Cost of Labor Cost of Material

Total Cost

FIG. 1. REQUISITION BLANK

TOTAL												DATE
												HOUSE MECHANIC
												CARPENTERS
												ELECTRICIAN
												PAINTER
												PIPE-FITTINGS &c.
												LUMBER
												ELECTRICAL SUPPLIES
												PAINT, &c.
												HARDWARE

COST

FIG. 2. COST SHEET FOR INDIVIDUAL JOB

the nature of the work and the time. This card is deposited at the office when he leaves at night. The next morning the time cards are looked over to note corrections and to mark the items of new work or repairs by the number under which the work is designated. The time is then transferred to the proper job card, Fig. 2. No attempt is made to keep the individual account of each man's time, but instead a division is made according to the trades. When the work is complete the total labor cost is easily obtained.

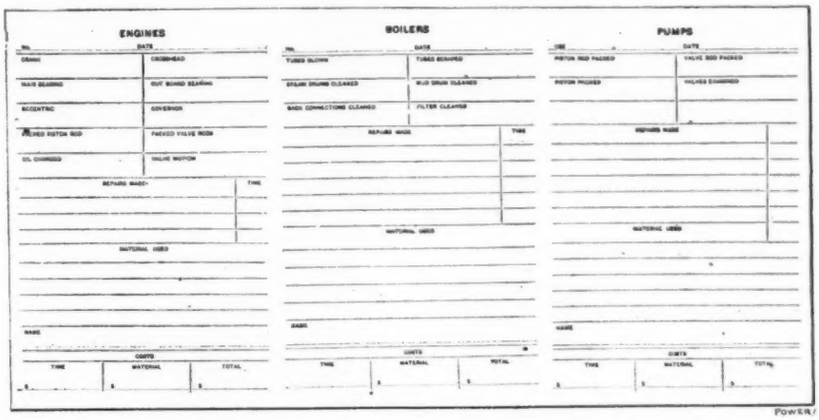


FIG. 3. FILE CARDS SHOWING WORK DONE ON ENGINES, BOILERS AND PUMPS

At the time an order is made out for material it is made in duplicate and the job number is marked on the carbon copy. When the invoice comes in for the material, it contains the number of the order, and the price of the material is put on the duplicate order which, in turn, is transferred to the card bearing the job number.

Thus is obtained a record of the total labor and material for repairs and new work, but it gives us no record of repairs on the separate parts of the equipment unless such be transferred from the time card. To avoid this there are separate cards for each piece of apparatus. These cards are shown in Figs. 3 and 4, and are given to the workman to fill out with the time card with which they are deposited at night. The next morning the cards are looked over to see if the wording is sufficiently clear to describe what was done, so that it could be understood several months afterward. The cost of labor and material is entered on the bottom and the card is filed away under a proper heading, each engine, boiler, elevator, etc., having its separate guide card.

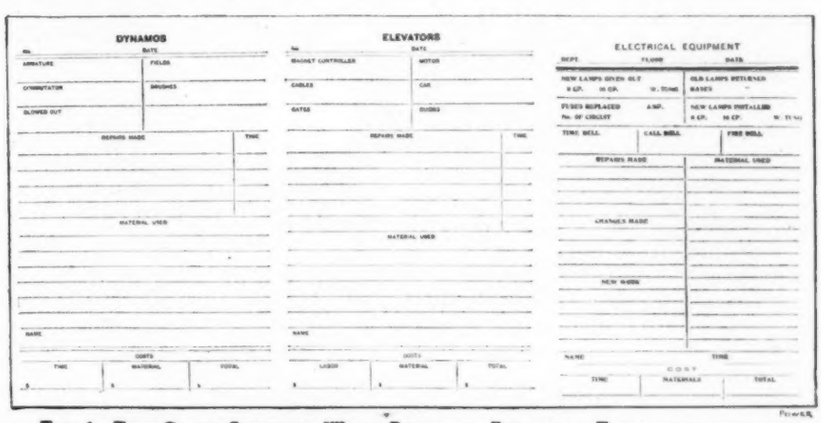
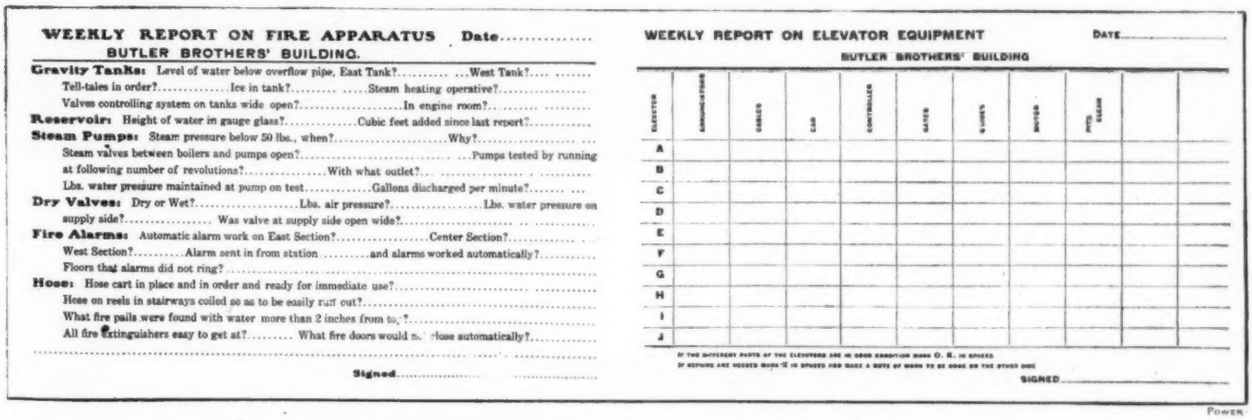


FIG. 4. FILE CARDS SHOWING WORK DONE ON DYNAMOS, ELEVATORS AND THE ELECTRICAL EQUIPMENT

These cards remain on file for reference at any time to see how often certain repairs are made or what the cost may be for any definite time. The time cards need not be preserved after the time is transferred to the job cards.

It costs very little to employ this system and a complete record as to the cost of repairs and new work is always at hand. It affords a means of locating the principal faults in the equipment which, by frequency of repair, warrants changing. It also gives a record of the length of time one packing lasts over another on pumps, engines, etc.

A system of weekly reports on the condition of the equipment is also used. Two forms, Figs. 5 and 6, show the style of report, the former being made out to show the condition of all fire apparatus in the plant. It is well to have these reports made out by different men alternating each week, as one is a check against the other. Any trouble with the apparatus is immediately repaired so that the system is always in working order. The same style of report is used in regard to elevator equipment, Fig. 6, so that any repairs needed for any of the elevators are brought constantly to the attention of the proper person. A report on water equipment, plumbing, toilets, etc., is also made so that a correct condition of the plant is always at hand. This in a large plant or building is difficult to obtain without some such system.


WEEKLY REPORT ON FIRE APPARATUS Date.....
BUTLER BROTHERS' BUILDING.
Gravity Tanks: Level of water below overflow pipe, East Tank?..... ...West Tank?.... .....
Tell-tales in order?.....Ice in tank?..... .....Steam heating operative?.....
Valves controlling system on tanks wide open?.....In engine room?..... .....
Reservoir: Height of water in gauge glass?.....Cubic feet added since last report?.....
Steam Pumps: Steam pressure below 50 lbs., when?.....Why?.....
Steam valves between boilers and pumps open?.....Pumps tested by running
at following number of revolutions?.....With what outlet?.....
Lbs. water pressure maintained at pump on test.....Gallons discharged per minute?..... ...
Dry Valves: Dry or Wet?.....Lbs. air pressure?.....Lbs. water pressure on
supply side?..... Was valve at supply side open wide?..... ..
Fire Alarms: Automatic alarm work on East Section?.....Center Section?.....
West Section?.....Alarm sent in from station .....and alarms worked automatically?.....
Floors that alarms did not ring?.....
Hose: Hose cart in place and in order and ready for immediate use?.....
Hose on reels in stairways coiled so as to be easily run out?.....
What fire pails were found with water more than 2 inches from to.?.....
All fire extinguishers easy to get at?..... What fire doors would n. close automatically?.....
.....
Signed.....
WEEKLY REPORT ON ELEVATOR EQUIPMENT DATE.....
BUTLER BROTHERS' BUILDING
ELEVATOR
CONNECTIONS
CABLES
CAR
CONTROLLER
GATES
GUIDES
MOTOR
PITCH CHAIN
A
B
C
D
E
F
G
H
I
J
IF TWO DIFFERENT PARTS OF THE ELEVATORS ARE IN GOOD CONDITION MARK O. K. IN SPACES
IF REPAIRS ARE NEEDED MARK "X" IN SPACES AND MAKE A NOTE OF WORK TO BE DONE ON THE OTHER SIDE
SIGNED.....
Power

FIGS. 5 AND 6. WEEKLY REPORT BLANKS ON FIRE APPARATUS AND ELEVATOR EQUIPMENT

The Largest Turbine in the World

On November 3, the largest turbine in the world was placed in service at the Waterside No. 1 station of the New York Edison Company.

The machine is of the Curtis vertical type, having a rated capacity of 20,000 kilowatts, or about 27,000 horsepower; sufficient to supply all the current for the city of Providence or any city of about 250,000 population. Alone it would supply a chain of cities such as Albany, Syracuse and Utica.

A striking example of the rapid development in prime movers and the concentration of power was afforded when the new unit, in being thrown onto the line, took over the load of seven large vertical reciprocating engines, any one of which occupied nearly as much space as the new machine. The latter stands 35 feet 7 inches above the base and is approximately 17 feet in diameter, covering an area of 297 square feet. The total weight is 420 tons.

The first of three 20,000-kilowatt Curtis turbines was placed in service at the Waterside station of the New York Edison Company on November 3. The machine is 35 feet high, covers an area of 297 square feet and weighs 420 tons.

The generator is of the four-pole type, running at 750 revolutions per minute and furnishing three-phase, 25-cycle currents at 6600 volts. In order to protect the windings against the effects of a short-circuit or a sudden rush of current in the line, choke coils are inserted in the leads.

The guaranteed steam consumption of the turbine when running with steam at 175 pounds gage and 100 degrees superheat and a 28½-inch vacuum, is as follows:

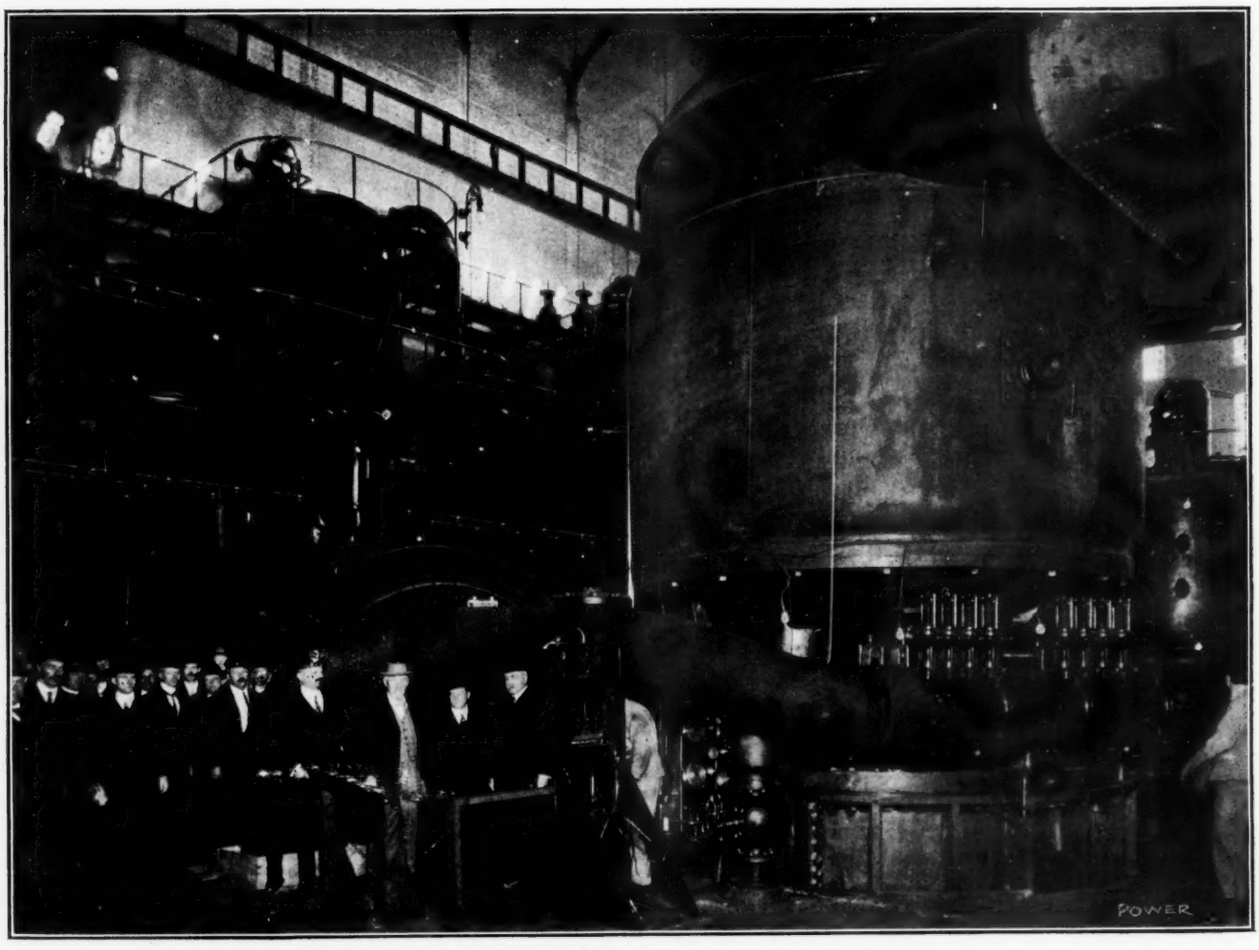
Load, Kilowatts	Steam, Pounds per Kilowatt-hour	Total Steam per Hour, Pounds
10,000	15	150 000
15,000	14.4	216,000
20,000	15	300,000

The exhaust steam is handled by a surface condenser placed in the foundation under the turbine. It is estimated that about 86,000,000 gallons of condensing water will be required per day when operating under full load.

A large air duct leading from the outside of the building to the upper part of the generator conveys 80,000 cubic feet of air per minute for cooling the generator windings.

The illustration shows the turbine about to be started by George B. Cortelyou, formerly Secretary of the Treasury and now president of the Consolidated Gas Company, of New York.

It is planned to install two more units similar to the one described, the three occupying the space formerly taken up by four 3500-kilowatt engine-driven units.



20,000-KILOWATT TURBINE BEING PLACED IN SERVICE

Philadelphia's Oldest Steam Engine

By A. D. Blake

Description of a steam engine which has been in continuous service since 1847. It is of the single-cylinder slide-valve type and develops 122 horsepower when running on 100 pounds steam pressure.

In striking contrast to the great 20,000-kilowatt turbine of the New York Edison Company, which is described on the opposite page and which represents the latest development in prime movers, is an old beam engine which has been in continuous service, part of the time both night and day, for the past 64 years.

This engine is doing duty at the plant of Wetherill & Bros.' white-lead works at 126 South Thirtieth street, Philadelphia, and, so far as can be ascertained, is the oldest engine in actual operation in that city. The engine was built in 1847 by J. T. Sutton & Co.

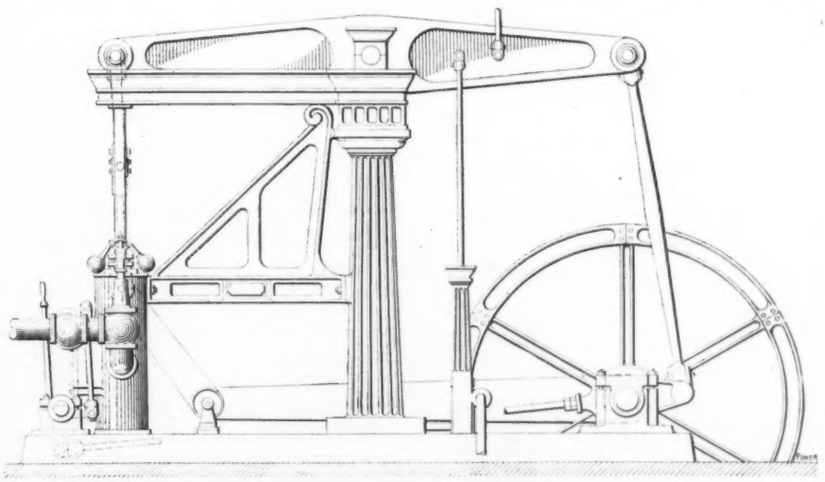


FIG. 1. ELEVATION OF ENGINE

It is of the plain slide-valve type (see Fig. 2), the valve yoke being worked off the rocker shaft which, in turn, is actuated by an eccentric on the main shaft. The cylinder is 15x48 inches and, although designed to develop 75 horsepower, it is now carrying a load of 122 horsepower when running on 100 pounds steam pressure.

The beam is carried by a central column 14 feet high, which formerly served as an open feed-water heater, the exhaust steam being led from the cylinder through the engine frame to the column, and the feed water flowing by gravity to a plunger pump worked from the beam. About two years ago, however, the use of this heater was discontinued.

The flywheel is about 14 feet in diameter and the connecting rod is attached to the center crank by a drag pin.

In addition to the machinery driven from the main shaft a vertical rod extending upward from the beam operates 12 plunger pumps through a system of bell cranks.

The chief engineer of the plant is J. M. Todd, who takes great pride in this relic, representing the engine practice of over half a century ago, and who is always pleased to show it to visitors.

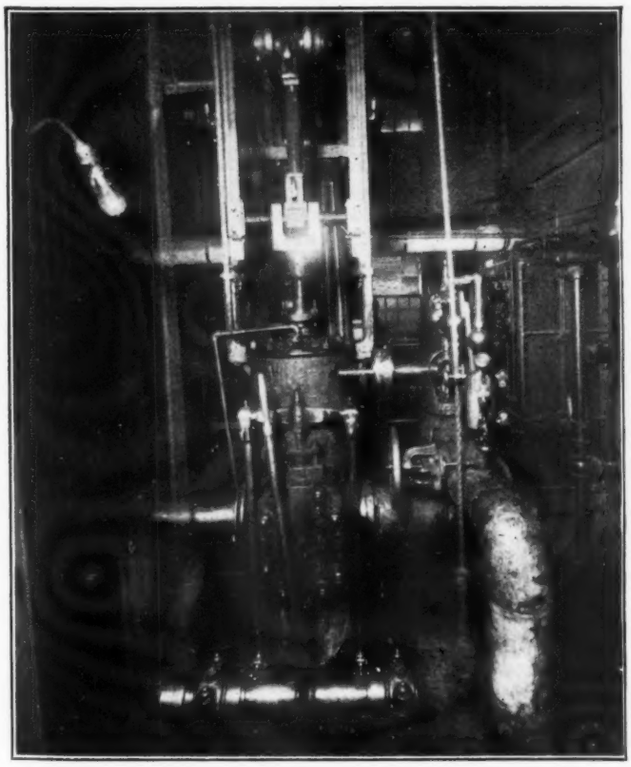


FIG. 2. SHOWING CYLINDER AND VALVE GEAR

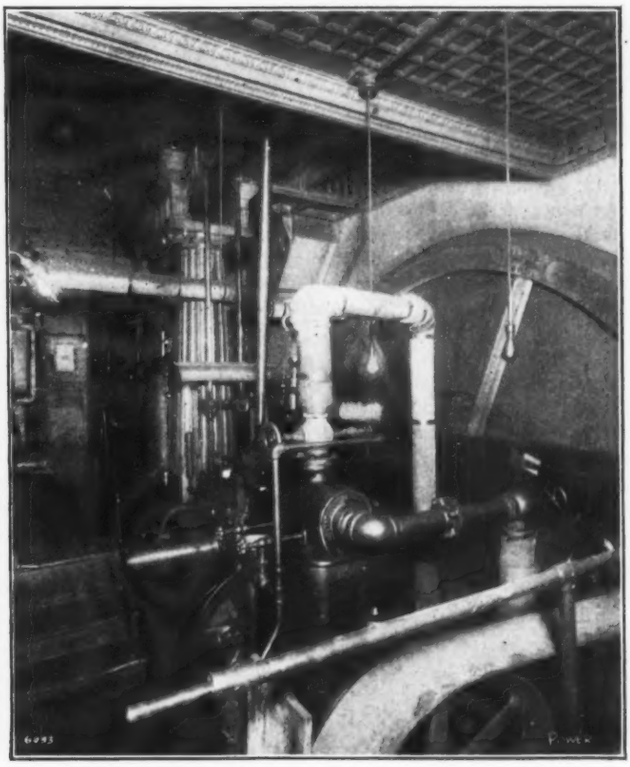


FIG. 3. CRANK END OF ENGINE. THE SMALL ENGINE IN FOREGROUND IS ANOTHER UNIT

The Power of the Atlantic Fleet

From every standard of comparison, the most notable fleet ever assembled by the United States was that reviewed by President Taft and Secretary of the Navy Meyer at New York on November 2. It involved the greatest number of American vessels ever mobilized, and the greatest total displacement and the maximum in fighting effectiveness probably ever gathered at one point by any nation.

Vessels number 102 *and cost* $123,000,000. *The total boiler capacity is* 1,000-000 *horsepower. Propelled at their full power all of the vessels would consume* 20,000 *tons of coal per day.*

Contrast in Displacement

As indicating something of the increased strength of the Navy, it is interesting to contrast the number of vessels and their total displacement which took part in other important American naval reviews. In the international naval review at New York in March, 1893, there were 14 naval vessels of all classes with an aggregate displacement of 39,-436 tons. President Roosevelt, in September, 1906, reviewed at Oyster Bay the Atlantic fleet, then comprising 45 vessels displacing 279,612 tons. During the Jamestown Exposition there was mobilized at Hampton Roads in June, 1907, a fleet of 33 vessels, displacing 285,251 tons. When the Atlantic and Pacific fleets met at San Francisco in May, 1908, they combined a total of 46 vessels displacing 407,924 tons, and in September, 1909, at the Hudson-Fulton celebration, 43 vessels were assembled with a total displacement of 316,762 tons.

This latest review at New York included 102 vessels of all classes, displacing about 577,285 tons; this does not include the eight submarines, of which no figures were available. Concurrently at Los Angeles a review was taking place of 24 vessels of 116,000 tons displacement, giving a grand total of 126 vessels displacing 694,000 tons. Perhaps the most striking evidence of the Navy's progress is that of all the vessels in the New York review, the only ones in commission at the time of the Spanish War were the battleships "Iowa," "Indiana" and "Massachusetts"; the gunboats "Castine," "Nashville," "Marietta" and "Petrel," a few of the small torpedo boats and some of the fleet auxiliaries.

An Analysis of the Fleet

The following table shows the number of vessels of each class in the Atlantic fleet and their total displacement:

CLASS AND DISPLACEMENT		Tons
24	battleships	366,864
2	armored cruisers	29,000
2	cruisers	6,950
22	destroyers	15,463
16	torpedo boats	2,994
8	submarines	....
3	tenders to torpedo fleet	8,466
4	gunboats	4,737
9	miscellaneous	40,733
8	colliers	93,938
1	oil tanker	6,159
3	tugs	1,981
102	vessels of all classes	577,285

Wide Use of Water-tube Boilers

Exclusive of the submarines, these vessels represent a total horsepower of 946,811, for the supplying of which there are 567 boilers aggregating 46,360 square feet of grate surface and 2,062,000 square feet of heating surface. All of the battleships, cruisers and torpedo boats except the battleship "Iowa" have water-tube boilers. This is a reversal of conditions during the Spanish-American War, when outside of the torpedo boats there were only four warships equipped with water-tube boilers.

Oil as Fuel

Seventeen of the destroyers burn oil as fuel and the four latest battleships, the "Delaware," "North Dakota," "Utah" and "Florida," burn oil in conjunction with coal. The fleet has a fuel-oil tank ship to carry the reserve fuel for these vessels, serving the corresponding function of the eight colliers carrying the coal supplies for the other vessels.

Coal Capacity

The aggregate coal-bunker capacity of the fleet is 81,450 tons. Adding to this the coal-cargo capacity of the colliers, 58,813 tons, the fleet can sail away with a total of 140,263 tons of coal. Propelled simultaneously at their full power, all of the vessels would consume coal at the rate of 20,000 tons a day.

Money Invested

The Government has invested in this fleet $123,397,400, exclusive of the cost of supplies of all kinds and the salaries of the officers and crew.

With its full complement the fleet would carry 27,344 men and 1650 officers, a total of 29,004.

Over Five Miles Long

The average speed of the vessels is 21.6 knots. The fastest vessel is the destroyer "Paulding," which is capable of making 32.8 knots. Placed end to end, touching, the vessels of the fleet would extend 29,942 feet, or over 5⅔ miles. Placed in single file 300 yards apart, the fleet would form a line nearly 23 miles long, and at an average speed of 10 knots an hour it would take about two hours to pass a given point.

Pumping Equipment

It is self-evident what such a fleet as this means to the ship-building and ordnance-manufacturing industries, but there are also less intimately associated industries that played an important part in the fleet's equipment. For example, the Blake & Knowles Steam Pump Works have installed pumping equipment on 65 of these vessels. This is a large percentage considering that nine of the remainder carry no steam pumps, including the submarines and one sailing vessel, and that eight of the others, principally colliers, were built abroad. The number of pumps this company has installed on the fleet exceeds 1000, and their cost represents nearly $1,250,000.

Pennsylvania Produces One Fifth of World's Coal

In the combined production of anthracite and bituminous coal Pennsylvania outranks any of the coal-producing countries of the world except Great Britain and Germany, and in 1910, reports the United States Geological Survey, it came within 10,000,000 short tons, or less than 5 per cent., of the output of Germany. Pennsylvania's production in 1910 was more than four times that of Austria-Hungary in 1909, more than five times that of France in 1910, and nearly 20 per cent. of the total world production. The industry, particularly in the bituminous districts, has kept pace with the manufacturing industries and has increased in considerably larger ratio than the population of the State and of the United States as a whole.

From 1814 to the close of 1910 the total production of anthracite had amounted to 2,180,323,469 short tons.

Elektrotechnika, of Budapest, Hungary, states that a power plant will shortly be erected on the River Cetina near Almissa in Dalmatia for the "Societa Anonima per la Utilizzazione delle Force Idrauliche delle Dalmazia, Triest, Austria. It is estimated that 200,000 horsepower is available at the waterfall, but of this only 40,000 horsepower will be at first utilized. The central station which is to be installed by Ganz & Co., Budapest, Hungary, will contain two 20,000-horsepower units and four 18,000-kilovolt-ampere three-phase transformers. The generators will be the largest in Europe, and the transformers the largest in the world. The distance from the falls to the plant, which is situated on the Mediterranean, is 16 miles. At the power house 55,000 volts will be available.

The Isochronous Governor

By Prof. V. Dwelshauvers-Dery

The common theory of the pendulum governor assumes that for each particular plane that the governor assumes the weight of the balls is just balanced by their centrifugal force.

The author points out that, owing to friction and to the resistance of the mechanism to which the governor is connected, there are two velocities of equilibrium for each position, and that any theory which does not take both into account must be in error.

The duty of a steam-engine governor is, first, to so proportion the expenditure of steam per stroke as to maintain the normal speed constant, whatever the useful load, so long as it remains between zero and the maximum assigned; second, to restore the speed to its normal value when variations have been produced by changes in the load. To effect this the governor is composed of two parts, one a centrifugal apparatus, sensitive to variations in speed and ordinarily called a tachometer; the other, an organ which, under the control of the tachometer, proportions the admission of steam per stroke, either by throttling or by varying the degree of expansion. For simplicity let it be supposed that this organ is a throttle valve. When the engine runs with a given load, at the normal speed, the movable sleeve of the governor must stand at the hight h (Fig. 1), corresponding to the useful load present, and when this load changes in such a way as to require another hight h', in order to maintain the speed at the normal, it is necessary that the sleeve should change its position to the h' plane.

The ordinary theory wrongfully assumes that what is commonly called the isochronous governor will realize this ideal. It says that for the sleeve to rest at the hight h when the engine is running at the normal speed, it is necessary that for all the positions between H_0 and H_1 the centrifugal force of the balls shall balance the weight of the balls and the sleeve, friction being neglected. It establishes, therefore, a relation between the hight h and these three forces in such a manner that, h being given, one can deduce the velocity of equilibrium u.

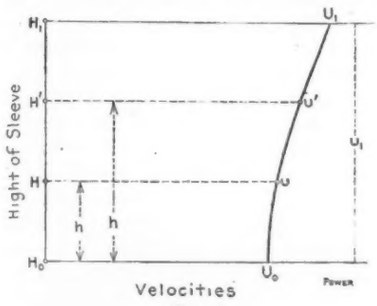


FIG. 1.

Let it be supposed that for a given governor the values of the speed of equilibrium u for different hights h have been so calculated as to permit the plotting of the diagram, Fig. 1, as follows: On the vertical H_0, H_1, starting from H_0, are laid out the ordinates as $h = H_0 H$. From $H_0 H_1$ as a base lay out horizontally the distances, as $H u$, proportional to the velocities u as calculated. The location in this way of the points u on the curve will serve—after the ordinary theory—to describe the qualities of a governor. For example: If the diagram described by these points is a straight vertical line, as u, in Fig. 1, the governor is assumed to be isochronous and perfect, and it is this quality which so many inventors have sought, happily in vain. But one governor is known which is really isochronous—that of Rankine—and if it were applied to an engine it would be found, instead of regulating it, to put the speed out of order.

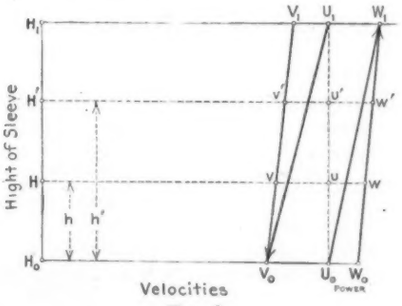


FIG. 2.

The ordinary theory takes into account but one single velocity of equilibrium u for the hight h, and assumes that the sleeve cannot maintain itself at that hight unless the engine runs at that velocity u. It assumes that if the actual velocity becomes ever so little more or less than u the sleeve must rise or fall. It takes account of the tachometer only, without considering the resistance R that the throttle valve offers to movement or the resistance due to friction. There are, therefore, in reality for each hight H two velocities of equilibrium, one w for the ascension of the sleeve and the other v for the descent, and the velocity u, which is greater than v and less than w, is nothing of a velocity of equilibrium for the governor.

In Fig. 2, indeed, suppose the sleeve to be at the hight h and the engine running at the normal speed $u = H u$. Suppose that suddenly the load is diminished and that in order to proportion the admission of steam per stroke to the normal velocity u, the sleeve must be raised to the hight h'. At first the actual speed of the engine will increase, but without raising the sleeve, because of the friction and the resistance R of the throttle valve, and it is necessary that the speed shall be increased and take a certain value w, in order that the sleeve may commence to rise. This speed w is, therefore, the velocity of equilibrium for ascension for the hight h. It is represented in Fig. 2 by the horizontal length $H w$. Operating in the same way for various hights h, the diagram $W_0 W_1$ of the velocities of equilibrium for the ascension may be plotted.

If, on the contrary, the sleeve being at the hight h, the actual velocity of the engine is diminished by a sudden increase of the load, the sleeve will not immediately descend. It is necessary that the centrifugal force shall be diminished until the weights are sufficiently in excess to put the throttle valve into motion. Then the speed, which takes the value $v = H v$ of the diagram, Fig. 2, is that which establishes the equilibrium of descent between the centrifugal force, the weight and the inevitable resistance. This value v being known for different hights h, one can plot the diagram $V_0 V_1$ of Fig. 2.

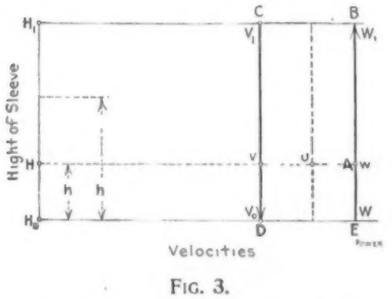


FIG. 3.

Therefore, there are for each position h of the sleeve two real speeds of equilibrium, one w for the upward movement, greater than u, and the other v for the downward movement, smaller than u, and it can readily be seen that the sleeve will remain wherever it is, whatever may be the load upon the engine, so long as the speed rests between w and v.

In consequence, the difference $w - v$ gives the measure of the sensibility of

the governor. The ordinary theory assumes that this sensibility is infinite, which is absurd. It wrongfully assumes also that the qualities of a governor, as revealed by the diagram of its tachometer, are independent of the throttle valve.

It is desirable in practice that there should be but a single velocity, that of the normal operation, at which the sleeve could remain at the hight at which it finds itself wherever it may be. In this condition a governor could be said to be perfect. Its diagram is given in $V_0 U_1$, $W_1 U_0$ of Fig. 2. The diagram of a governor rigorously isochronous would be that represented in Fig. 3 by w = constant and v = constant. The two diagrams, that of v and of w, are straight-line verticals, as well as that of u, but it should not be supposed that because a governor has been calculated in such a way that the velocity u is constant it will for that reason be isochronous in reality. Aside from the governor of Rankine, among the immense variety of governors invented to satisfy the condition u = constant, no other governor is known which, with a constant resistance R of the throttle valve, would be really isochronous. All have diagrams proving

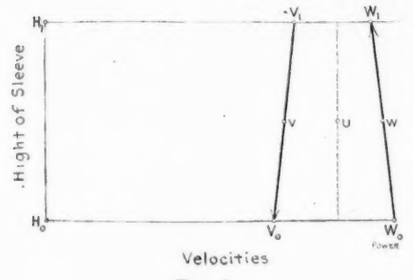


FIG. 4.

that they operate at times in an inverse direction. The most reputable have a diagram such as that in Fig. 4, showing that the governor operates very well during the descent but in the inverse direction during the ascent, since the velocity of equilibrium for the ascension W_0 in the lower position is greater than the velocity of equilibrium W_1 in the higher.

But there is more. A perfectly isochronous governor, Fig. 3, would derange the engine instead of regulating it. Suppose the sleeve at the hight h (Fig. 3) and the load on the engine corresponding to the velocity u. Suddenly a part of the load is removed, and in order that the speed shall remain equal to u the sleeve must be moved to the hight h'. The actual velocity will increase, and the sleeve will rise when that velocity has become equal to w; but as soon as that value is attained, the sleeve will rise with greater and greater velocity and nothing will stop it until it is arrested by the upper collar at H_1, and there it will prevent the admission of any steam at all if the governor is correctly set. But then the actual speed will diminish as the engine is no longer supplied with steam, and will finish by becoming equal to v; at this moment the sleeve will fall and keep on falling until it is arrested by the lower collar at H_0 opening the throttle valve completely. Then the velocity will increase and soon become equal to W_0, and the sleeve will precipitate itself again toward the upper collar. There will thus be established periods of greater and less velocity, with a complete unsettlement of the regulation of the engine, and it would be impossible to foresee many circumstances which might influence these events in such a manner as to interfere with and ameliorate the action which we have described.

To recapitulate, the ordinary theory of governors is false, because it does not take into account the resistance of the throttle valve and of the friction opposing the movement of the governor sleeve; that it deals with but one velocity of fictitious and not true equilibrium, instead of the two velocities of actual equilibrium; that it is incapable of defining the sensibility of a governor; that it does not offer a means of satisfying the exigencies of practice. The real, practical governor has for a diagram that indicated in Fig. 2 by $V_0 U_1$, $W_1 U_0$. Ordinarily, in practice the resistance of the throttle valve is variable, and it is by guessing that the engineer regulates the governor, without being able to explain to himself precisely why, so as to realize somewhere near this diagram.

The real theory of the governor was given by Monsieur Ch. Beer, engineer at Liège, Belgium (1877), and developed by the writer.

Sampling Coal

BY CHARLES M. ROGERS

Many methods have been proposed and considerable difficulty has been encountered in arriving at the most accurate and easiest way for sampling coal and preparing it for analysis. To the writer's knowledge, the sampling scheme here described is not practised in many places, although it proves to be inexpensive and satisfactory, especially where the coal is received in cars and has to be sampled and analyzed regularly each day. Of course, this method of car sampling could not be used for any other than slack coal, or coal sufficiently small to be admitted into a 1½- or 2-inch pipe.

A 2-inch iron pipe 5 feet long is closed at one end and the open end is chamfered or sharpened on the outer edge; this is driven vertically to, or nearly to, the bottom of each car at six different places. When drawn up the pipe is full of coal which represents a sample from top to bottom of the car, and it is easily made to fall out into a bucket by a few slight taps with a hammer.

The samples thus taken from all the cars are carried to a convenient place in the boiler room and thoroughly mixed in a container which is of sufficient size so that when it contains the samples from all the cars it is about one-half full. It is cylindrical in shape, is made of ⅛-inch sheet iron, and is provided with a bearing on each side for mounting purposes, and a top which is easily held fast by clamp screws. The spindle which passes through the center and upon which the mixer revolves is fitted with arms which project to the sides so as to insure a thorough mixture of the coal.

After the coal has been thoroughly mixed, which is effected by about twenty-five revolutions of the spindle, the lid is removed and it is dumped upon the platform below. The laboratory sample of approximately 4 quarts is then taken by quartering down in the usual manner. The remainder is shoveled into the stoker magazine or into the bucket conveyer which passes within 5 feet of the mixer.

In the laboratory the entire sample is run through a crusher which delivers it at ¼-inch mesh or smaller. This is then quartered down twice, and the remaining sample, about one quart, is run through a coffee grinder. About 200 grams are then used for the moisture determination and a portion of the remainder is properly labeled and put away for further reference.

After the moisture is expelled and its percentage determined, the coal is run through a pulverizer, which, at one grinding, delivers it at 100 mesh. About 25 grams of this final sample is then put in a desiccator for determinations of heat value, ash, volatile combustible matter, fixed carbo. and sulphur.

The heat value is determined by an Atwater oxygen-bomb calorimeter, and the sulphur by the Eschka-Fresenius method. The ash, volatile matter and fixed-carbon determinations closely resemble those recommended by the special committee appointed by the American Chemical Society.

There should be no question as to the accuracy of this method in furnishing a representative sample. No matter how large or how small a car is as compared with the others, the same proportions exist in the final sample that exist in the cars.

The time required outside of the laboratory work is less than one hour. In the laboratory the coal can be reduced from its original size to 100 mesh in about 15 minutes, excluding the one hour which is required for the moisture determination before being pulverized. The crusher, grinder and pulverizer are driven by a small motor.

The chief engineer of a British engine, boiler and electrical insurance company is reported by *Engineering* as saying that out of every 45 engines insured, 20 are driven by gas.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

The Bell Single Phase Motor

With a view to meeting the requirements of heavy starting torque and moderate initial-current rush, where only alternating-current supply is available, the Bell Electric Company, Garwood, N. J., has brought out a line of single-phase motors the construction of which is indicated in the accompanying illustrations.

The motor starts on the repulsion principle and upon reaching a speed slightly below normal is changed, by the action of a centrifugal governor, to the equivalent of a squirrel-cage induction motor. This method is not new, of course, and the electrical principles involved are therefore not discussed in this article.

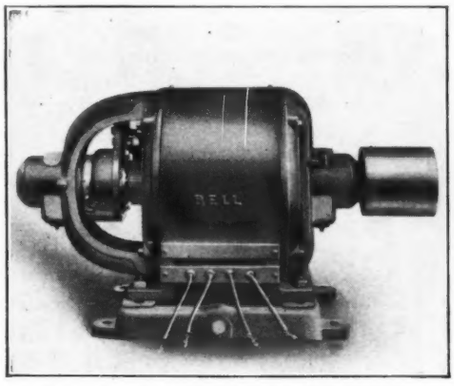


FIG. 1. BELL SINGLE-PHASE MOTOR

FIG. 2. STATOR FRAME

Fig. 1 is a perspective view of the complete machine and Fig. 2 is an end view of the stator core and housing, which are exactly like those of the ordinary induction motor. The coil slots of the stator are partly closed and the winding is of the usual single-phase type. The rotor or armature is very similar in appearance to that of a direct-current motor, as Fig. 3 indicates. The winding is of the distributed type connected to a commutator in the same manner as that of a direct-current machine.

At the speed where the machine is changed from a repulsion to an ordinary induction motor, the centrifugal governor overcomes a restraining spring and forces a short-circuiting ring against the end of the commutator. The construction of the short-circuiting ring is shown in Fig. 4, which also shows the commutator and governor. The ring is slotted radially around its internal circumference, in order to provide good electrical contact between it and each commutator bar independently. Fig. 5 shows the governor and short-circuiting ring in position on the shaft.

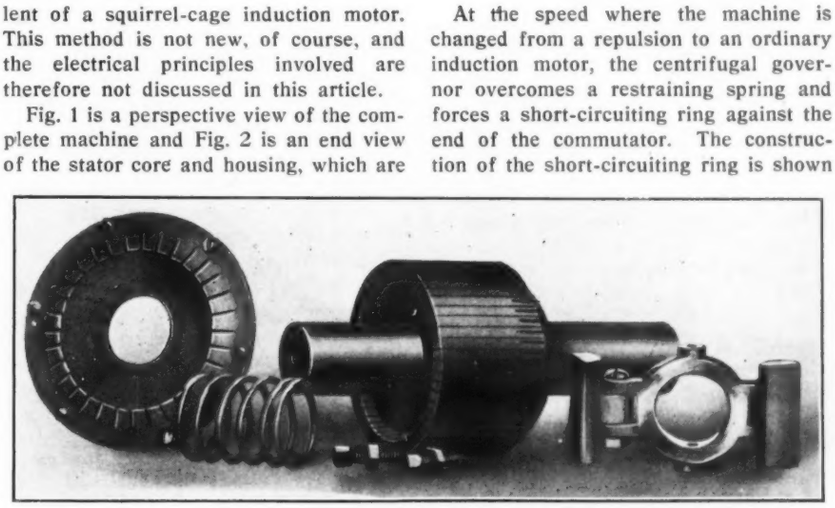


FIG. 4. COMMUTATOR AND SHORT-CIRCUITING MECHANISM DISASSEMBLED

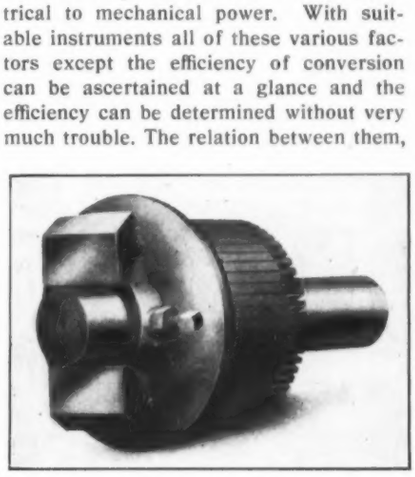


FIG. 5. PARTS IN FIG. 4 ASSEMBLED

Fig. 6 is a chart showing the performance of the 5-horsepower machine illustrated in Fig. 1. The free (synchronous) speed is 1800 revolutions per minute and the frequency 60 cycles. This chart does not show the starting current taken. The builder states that it is less than the current per phase taken by standard polyphase motors of equal power.

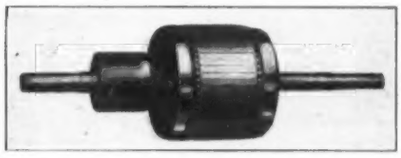


FIG. 3. ARMATURE OF BELL SINGLE-PHASE MOTOR

Power and Current in Three Phase Circuits

BY CECIL P. POOLE

The current per wire of a balanced three-phase circuit depends upon the power transmitted, the power factor of the circuit and the voltage. The power transmitted is determined, of course, by the mechanical power delivered by the motor or motors in the circuit and by the efficiency of conversion from electrical to mechanical power. With suitable instruments all of these various factors except the efficiency of conversion can be ascertained at a glance and the efficiency can be determined without very much trouble. The relation between them, however, even when all of the requisite instruments are at hand, cannot be determined without more or less tedious figuring, and the tables will be found of considerable convenience in reducing the amount of such figuring.

Table 1 shows the electrical power in kilowatts taken from the line for each horsepower delivered at the pulley or shaft of a motor, over the entire practical range of efficiencies. This table may be used regardless of voltages, power factors or other considerations, for the reason that it deals only with power and therefore involves merely the reduction of electrical to mechanical power at the various efficiencies. Electrical power, which is almost invariably measured in

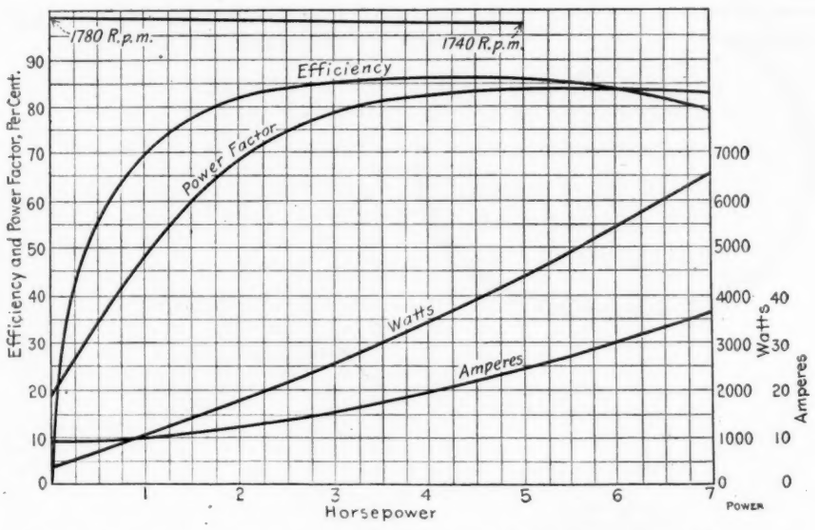


FIG. 6. TEST CURVES OF 5-HORSEPOWER, 60-CYCLE BELL MOTOR, AT 220 VOLTS

TABLE 1

Efficiency	Horsepower per Kilowatt	Kilowatts per Horsepower	Efficiency
60	0.805	1.243	60
61	0.818	1.222	61
62	0.831	1.203	62
63	0.845	1.184	63
64	0.858	1.165	64
65	0.872	1.147	65
66	0.885	1.130	66
67	0.898	1.113	67
68	0.912	1.097	68
69	0.925	1.081	69
70	0.939	1.065	70
71	0.952	1.050	71
72	0.966	1.036	72
73	0.979	1.021	73
74	0.992	1.008	74
75	1.006	0.994	75
76	1.019	0.981	76
77	1.033	0.968	77
78	1.046	0.956	78
79	1.059	0.944	79
80	1.073	0.932	80
81	1.086	0.921	81
82	1.100	0.910	82
83	1.113	0.898	83
84	1.126	0.888	84
85	1.140	0.877	85
86	1.153	0.867	86
87	1.167	0.857	87
88	1.180	0.848	88
89	1.193	0.838	89
90	1.207	0.829	90
91	1.220	0.820	91
92	1.234	0.811	92
93	1.247	0.802	93
94	1.261	0.793	94

TABLE 2. AMPERES PER KILOWATT IN EACH LEG OF A BALANCED THREE-PHASE LINE

Power Factor	Volts between Any Two Wires														
	100	110	125	200	220	250	440	500	550	1100	1150	2200	2300	6600	13,200
50	11.55	10.50	9.24	5.77	5.25	4.62	2.62	2.31	2.10	1.050	1.004	0.525	0.502	0.175	0.0875
51	11.32	10.29	9.06	5.66	5.15	4.53	2.57	2.26	2.06	1.029	0.985	0.515	0.492	0.172	0.086
52	11.10	10.09	8.88	5.55	5.05	4.44	2.52	2.22	2.02	1.009	0.966	0.505	0.483	0.168	0.084
53	10.89	9.90	8.72	5.44	4.95	4.36	2.47	2.18	1.98	0.990	0.947	0.495	0.474	0.165	0.0825
54	10.69	9.72	8.55	5.34	4.86	4.28	2.43	2.14	1.94	0.972	0.930	0.486	0.465	0.162	0.081
55	10.50	9.54	8.40	5.25	4.77	4.20	2.38	2.10	1.91	0.954	0.913	0.477	0.456	0.159	0.0795
56	10.31	9.37	8.25	5.15	4.69	4.12	2.34	2.06	1.87	0.937	0.897	0.469	0.448	0.156	0.078
57	10.13	9.21	8.10	5.06	4.60	4.05	2.30	2.03	1.84	0.921	0.881	0.460	0.440	0.153	0.0765
58	9.96	9.05	7.96	4.98	4.53	3.98	2.26	1.99	1.81	0.905	0.866	0.453	0.433	0.151	0.0755
59	9.79	8.90	7.83	4.89	4.45	3.92	2.22	1.96	1.78	0.890	0.851	0.445	0.425	0.148	0.074
60	9.62	8.75	7.70	4.81	4.37	3.85	2.18	1.92	1.75	0.875	0.837	0.437	0.418	0.146	0.073
61	9.46	8.61	7.57	4.73	4.30	3.79	2.15	1.89	1.72	0.861	0.823	0.430	0.411	0.143	0.0715
62	9.31	8.47	7.45	4.65	4.23	3.72	2.11	1.86	1.69	0.847	0.810	0.423	0.405	0.141	0.0705
63	9.17	8.33	7.33	4.58	4.16	3.67	2.08	1.83	1.67	0.833	0.797	0.416	0.398	0.139	0.0695
64	9.02	8.20	7.22	4.51	4.10	3.61	2.05	1.80	1.64	0.820	0.784	0.410	0.392	0.137	0.0685
65	8.88	8.07	7.10	4.44	4.03	3.55	2.02	1.78	1.61	0.807	0.772	0.403	0.386	0.134	0.0670
66	8.75	7.95	7.00	4.37	3.97	3.50	1.99	1.75	1.59	0.795	0.761	0.397	0.380	0.132	0.066
67	8.62	7.83	6.89	4.31	3.91	3.45	1.96	1.72	1.57	0.783	0.749	0.391	0.374	0.130	0.065
68	8.49	7.72	6.79	4.24	3.86	3.40	1.93	1.70	1.54	0.772	0.738	0.386	0.369	0.129	0.0645
69	8.37	7.61	6.69	4.18	3.80	3.34	1.90	1.67	1.52	0.761	0.728	0.380	0.364	0.127	0.0635
70	8.25	7.50	6.60	4.13	3.75	3.30	1.87	1.65	1.50	0.750	0.717	0.375	0.359	0.125	0.0625
71	8.13	7.39	6.50	4.06	3.69	3.25	1.85	1.63	1.48	0.739	0.707	0.369	0.354	0.123	0.0615
72	8.02	7.29	6.41	4.01	3.64	3.20	1.83	1.60	1.46	0.729	0.697	0.364	0.349	0.121	0.0605
73	7.91	7.19	6.33	3.95	3.59	3.16	1.80	1.58	1.44	0.719	0.688	0.359	0.344	0.120	0.0600
74	7.80	7.09	6.24	3.90	3.54	3.12	1.77	1.56	1.42	0.709	0.678	0.354	0.339	0.118	0.059
75	7.70	7.00	6.16	3.85	3.50	3.08	1.75	1.54	1.40	0.700	0.669	0.350	0.334	0.117	0.0585
76	7.60	6.91	6.08	3.80	3.45	3.04	1.73	1.52	1.38	0.691	0.661	0.345	0.330	0.115	0.0575
77	7.50	6.82	6.00	3.75	3.41	3.00	1.70	1.50	1.36	0.682	0.652	0.341	0.326	0.114	0.057
78	7.40	6.73	5.92	3.70	3.36	2.96	1.68	1.48	1.35	0.673	0.644	0.336	0.322	0.112	0.056
79	7.31	6.64	5.85	3.65	3.32	2.92	1.66	1.46	1.33	0.664	0.636	0.332	0.318	0.111	0.0555
80	7.22	6.56	5.77	3.61	3.28	2.88	1.64	1.44	1.31	0.656	0.628	0.328	0.314	0.109	0.0545
81	7.13	6.48	5.70	3.56	3.24	2.85	1.62	1.43	1.30	0.648	0.620	0.324	0.310	0.108	0.054
82	7.04	6.40	5.63	3.52	3.20	2.82	1.6	1.41	1.28	0.640	0.612	0.320	0.306	0.107	0.0535
83	6.96	6.32	5.56	3.48	3.16	2.78	1.58	1.39	1.26	0.632	0.605	0.316	0.302	0.105	0.0525
84	6.87	6.25	5.50	3.43	3.12	2.75	1.56	1.37	1.25	0.625	0.598	0.312	0.299	0.104	0.052
85	6.79	6.17	5.43	3.39	3.09	2.72	1.54	1.36	1.23	0.617	0.591	0.309	0.295	0.103	0.0515
86	6.71	6.10	5.37	3.35	3.05	2.68	1.52	1.34	1.22	0.610	0.584	0.305	0.292	0.102	0.051
87	6.64	6.03	5.31	3.32	3.01	2.66	1.51	1.33	1.21	0.603	0.577	0.301	0.288	0.100	0.05
88	6.56	5.96	5.25	3.28	2.98	2.62	1.49	1.31	1.19	0.596	0.570	0.298	0.285	0.099	0.0495
89	6.49	5.90	5.19	3.24	2.95	2.59	1.47	1.30	1.18	0.590	0.564	0.295	0.282	0.098	0.049
90	6.41	5.83	5.13	3.20	2.91	2.56	1.46	1.28	1.17	0.583	0.558	0.291	0.279	0.097	0.0485
91	6.34	5.77	5.08	3.17	2.88	2.54	1.44	1.27	1.15	0.577	0.552	0.288	0.276	0.096	0.048
92	6.28	5.70	5.02	3.14	2.85	2.51	1.42	1.26	1.14	0.570	0.546	0.285	0.273	0.095	0.0475
93	6.21	5.64	4.97	3.10	2.82	2.48	1.41	1.24	1.13	0.564	0.540	0.282	0.270	0.094	0.047
94	6.14	5.58	4.91	3.07	2.79	2.46	1.39	1.23	1.12	0.558	0.534	0.279	0.267	0.093	0.0465
95	6.08	5.52	4.86	3.04	2.76	2.43	1.38	1.22	1.10	0.552	0.528	0.276	0.264	0.092	0.046
96	6.01	5.47	4.81	3.00	2.73	2.40	1.37	1.20	1.09	0.547	0.523	0.273	0.261	0.091	0.0455
97	5.95	5.41	4.76	2.97	2.70	2.38	1.35	1.19	1.08	0.541	0.518	0.270	0.259	0.090	0.045
98	5.89	5.36	4.71	2.94	2.68	2.35	1.34	1.18	1.07	0.536	0.512	0.268	0.256	0.089	0.0445
99	5.83	5.30	4.66	2.91	2.65	2.33	1.32	1.17	1.06	0.530	0.507	0.265	0.254	0.088	0.044

kilowatts, is equivalent to mechanical horsepower multiplied by 0.746, because 746 watts are the practical equivalent of one horsepower. But for the losses in the motor this simple multiplication would be all that is necessary to translate mechanical into electrical units. Taking efficiency into consideration, the product of 0.746 and the mechanical horsepower must be divided by the efficiency, written in decimal form, to find the actual kilowatts of intake. Thus, *multiply the horsepower by* 0.746 *and divide the result by the efficiency in hundredths.** For example, if the mechanical horsepower is 50 and the efficiency 90 per cent., the motor will take $\frac{0.746 \times 50}{0.90} = 41.44$ kilowatts.

The two sections of Table 1 were calculated by means of the foregoing formula and its transposition. The object in arranging the table in this way is to facilitate working in either direction, which will be made clearer later on.

Table 2 shows the amperes in each leg of a balanced three-phase circuit for each kilowatt of actual power transmitted at any of the various standard voltages and at different power factors from 50 per cent. up. For example, at 220 volts, with a power factor of 80 per cent., the current in each leg of the circuit will be 3.28 amperes for each kilowatt of power transmitted. This is found by following down the power-factor column to the number 80 and then taking the number in the column under 220 volts which is on the same line with it. Again, suppose the power factor is 86 per cent. and the voltage 250; following down the power-factor column until the number 86 is reached, trace along that line into the table until the 250-volt column is reached; in that column is the number 2.68, which is the number of amperes per wire for each kilowatt of power.

The following examples will illustrate the use of the two tables in combination. Suppose a 20-horsepower 250-volt motor is to be installed and the manufacturers put its efficiency at 88 per cent. and its power factor at 85 per cent. It is desirable to know how much current per leg the motor will require in order to determine the size of wire to be installed. Referring to Table 1 and following down the efficiency column to the figure 88, on that line in the kilowatts column the number 0.848 is found; this is the fraction of a kilowatt per horsepower required by the motor. Multiplying this by 20 gives 16.96, or practically 17, kilowatts for the electrical intake of the motor. Now referring to Table 2, starting at 85 per cent. power factor in the left-hand column and following along that line to the 250-volt column, the number 2.72 is found. This is the current per kilowatt, and multiplying it by the 17 kilowatts taken from Table 1 gives 46.24 amperes per wire as the full-load motor current. Adding 25 per cent. margin for starting current, as required by the insurance rules, the capacity of each wire must be not less than 58 amperes.

The tables are also convenient in determining the efficiency of a motor without going through the tedious arithmetical process which is necessary no matter how many instruments may be available. For example, suppose a 550-volt three-phase motor is being tested with a prony brake and when loaded to 30 horsepower takes 30½ amperes in each leg of the circuit with the power-factor meter showing 87 per cent.; what is the efficiency of the motor? Referring to Table 2, it will be found by tracing from 87 per cent. power factor in the left-hand column over to the 550-volt column that 1.21 amperes represent one kilowatt; therefore, 30½ amperes represent 30.5 ÷ 1.21 = 25.2 kilowatts. Dividing this by the brake horsepower gives 25.2 ÷ 30 = 0.84 as the fraction of a kilowatt which the motor is taking from the line per horsepower delivered. Tracing down the third column of Table 1 until the nearest number to this (0.838) is reached, the number 89 will be found opposite it in the efficiency column; the efficiency of the motor, therefore, is practically 89 per cent.

Suppose that a motor was driving a load which could not be measured directly and it was desired to get an idea of what the load was and what power factor the motor was showing, no power-factor meter being available. With a wattmeter, ammeter, voltmeter and the manufacturer's performance chart, which may be had with any motor, the behavior of the machine can be analyzed with very little trouble. The voltage should be normal in order to avoid troublesome arithmetic and more troublesome corrections. Suppose the motor to be a 15-horsepower 220-volt machine, the electrical intake 7 kilowatts and the current per leg 23 amperes. Dividing 23 by 7 gives 3.29 as the current per kilowatt. Following down the 220-volt column in Table 2, the nearest number to 3.29 is 3.28, and this is in line with 80 per cent. power factor in the left-hand column.

Now referring to the manufacturers' chart, suppose that it shows that at the load where the motor power factor is 80 per cent. its efficiency is 84 per cent. Table 2 shows that at 84 per cent. efficiency each kilowatt of intake is equivalent to 1.126 horsepower at the pulley. The intake is 7 kilowatts; the power being delivered, therefore, is 7 × 1.126 = 7.882, or practically 7.9, horsepower. Although this method will not always give absolutely correct results, it is close enough for all practical purposes.

The right-hand portion of Table 2 is useful for getting an idea of the power factor of a line when no meter is available for that purpose. It is only necessary to divide the current per leg by the kilowatts and to find the result in the table. For example, suppose the ammeter in one leg of a 2300-volt circuit showed 200 amperes, and the indicating power meter 625 kilowatts. The current per kilowatt would be 200 ÷ 625 = 0.32 ampere. The nearest numbers to this in the 2300-volt column of Table 2 are 0.318 and 0.322, which correspond to 79 and 78 per cent. power factors; as the exact current per kilowatt is half way between 0.318 and 0.322, the power factor is half way between 79 and 78, or 78½ per cent. Fractions of 1 per cent., however, are of no importance so far as the power factor or its influence on the circuit is concerned.

*In the form of an equation:

$$\frac{0.746 \times h.p.}{Eff.} = kw.$$

and the transposition is

$$\frac{Kw. \times eff.}{0.746} = h.p.$$

LETTERS

Mr. Hawkins' Compressor Motor

Some time ago I had almost exactly the same trouble with a motor operating an ice machine as that described by J. C. Hawkins in the October 31 issue of POWER. My motor was a 5-horsepower shunt-wound 220-volt machine and had had one new commutator in three years and needed another. Stop its sparking I could not, although I tried everything I knew and some things I did not. The motor did not seem to be overloaded, yet it sparked so badly and ran so hot that I had to keep a little desk fan blowing on it all the time. Finally, I built up the foundation so as to put the motor well up in the air (it is located in a dark, damp basement) and on top of the concrete I bolted two 6x6-inch pine timbers and to these bolted a 10-horsepower motor—and my troubles were over. I have to wipe the commutator of this motor occasionally and once in a great while lightly sandpaper it.

A friend of mine had the same trouble. He raised his motor farther up away from the ground and used a soft graphite brush; he thinks the soft brush did the business. Mr. Hawkins might try the soft brush; a compound-wound motor would not help him any. I do not think the action of the compressor has anything to do with the sparking. I have a good many motors on different kinds of service and the one I have just mentioned was the only one to give me trouble. I think it was the location and a little too heavy a load. If the brushes chatter, the mica is high and Mr. Hawkins needs to use a commutator stone.

C. A. SCOTT.

Wales, Wis.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Test of an Atlas Diesel Oil Engine

The Atlas Engine Works, of Indianapolis, some time ago took up the manufacture of Diesel-type oil engines and during the summer just closed a 300-horsepower unit was put through a comprehensive test under the supervision of C. E. Sargent, consulting engineer. Following is an abstract of Mr. Sargent's official report:

The object of the test was to determine the quantity of fuel used per unit of output, the speed of the engine under all conditions of load, and the cost of fuel per kilowatt-hour delivered to the switchboard.

The engine tested was a vertical, two-cylinder, single-acting machine, with cylinders 20 inches in diameter and a stroke of 30 inches; it operates on the four-stroke cycle. The engine was direct coupled to a 250-volt, 175-kilowatt, direct-current generator; the speed of engine and generator was 175 revolutions per minute.

The compressed air for injection and starting was furnished by a belt-driven three-stage Ingersoll-Rand compressor, driven by a 25-horsepower General Electric motor; this motor also furnished power for a Gould triplex pump which circulated the jacket water through the engine jackets.

A shop load of lights and motors was used in the tests, and it was maintained as near constant as possible by hand manipulation of the rheostat. The engine had run about 2800 hours under load when the tests were made.

The fuel oil was furnished to the engine oil pump by gravity from an elevated tank equipped with a sight-feed glass column. The hight of the oil was noted at the beginning of each test and the quantity of oil pumped into the tank to restore the level was weighed at each reading. A chemical analysis of the fuel oil used showed 19,149 B.t.u. per pound; the specific gravity was 29.9 degrees Baumé, making the weight 7.295 pounds per gallon.

All readings were taken simultaneously, and a log of each run was made. Seven runs of from 1 to 4 hours each were made, varying the load from the smallest that could be run in parallel with the steam-driven generator to the heaviest load the generator could carry without overheating.

The variation in speed between the lightest load and 25 per cent. overload did not exceed 2 per cent., and the engine showed no tendency to race with light loads or overreach with a change of loads.

Table 1 is the log of one of the full-load tests and Table 2 is a summary of all of the tests. The principal results of the tests are plotted on the chart, Fig. 2, for ready comparison and concise presentation. Fig. 1 shows exact facsimiles of some representative indicator diagrams taken during this series of tests.

TABLE 1. LOG OF ONE OF THE FULL LOAD RUNS

Time	Injection pressure in Atmospheres	Revolutions per Minute of Engine Shaft	Difference	Revolutions per Minute by Tachometer	Pounds Fuel Oil	Temp. of Jacket Water			Pounds Cooling Water	Amperes at Board	Volts at Board	Kilowatt-hrs. from Dynamo	Difference	Kilowatt-hrs. to Pump and Compressor	Difference	Temperature, General Field
						Entering Jackets	Discharge									
							No. 1 Cyl.	No. 2 Cyl.								
1:00	60	8,580		173		93	186	180		340	225	90,364		47,269		180
1:30	72	3,738	5,158	172	62	94	175	178	1,200	940	235	90,462	98	47,282	13	185
2:00	72	8,897	5,159	172	65	94	177	204	1,600	900	235	90,567	105	47,297	15	190
2:30	73	4,048	5,151	172	65	95	192	194	1,200	900	230	90,672	105	47,312	15	200
3:00	73	9,210	5,162	172	63	96	195	188	1,600	880	230	90,775	103	47,327	15	205
3:30	73	4,367	5,157	172	62	96	192	192	1,200	875	230	90,878	103	47,342	15	218
4:00	73	9,530	5,163	172	66	97	194	194	1,600	890	225	90,981	103	47,357	15	222
4:30	72	4,688	5,158	171	67	97	194	190	1,200	880	235	91,084	103	47,372	15	226
5:00	72	9,852	5,164	171	62	97	190	185	1,463	800	235	91,187	103	47,386	14	230
Total.....	640	41,272	41,272	1,547	512	859	1,695	1,705	11,063	7,405	2,080	823	823	117	117	1,856
Average...	71.1	171.9	171.9	171.9	128*	95.4	188.3	189.4	2,765.75*	822.8	231.1	205.75†	205.75†	29.25†	29.25†	206

*Per hour. †Kilowatts.

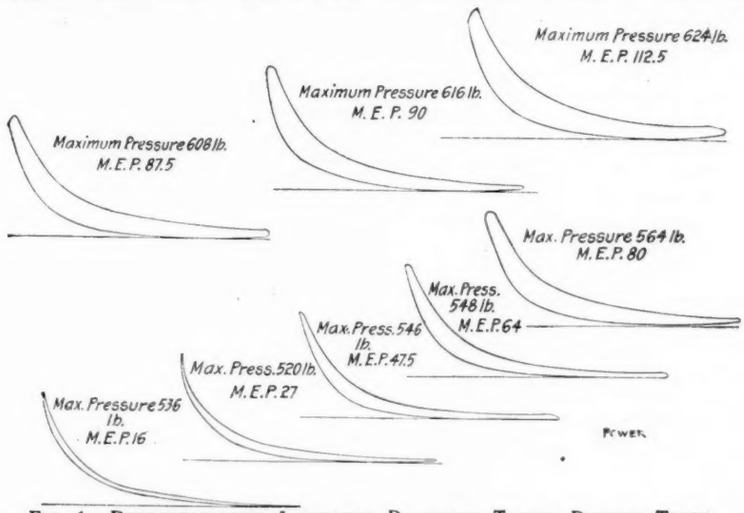


FIG. 1. REPRESENTATIVE INDICATOR DIAGRAMS TAKEN DURING TESTS

TABLE 2. SUMMARY OF ATLAS ENGINE TESTS

Duration of test in hours	1	1.5	3	2	2.5	4	1
Load in kilowatt-hours by switchboard meter	67.0	83.3	132.0	173.5	200.4	205.75	249.0
Kilowatts to compressor by wattmeter	24.75	22.66	23.6	25.5	29.6	29.25	31.0
Transmission losses to compressor, 23.6 per cent	5.84	5.34	5.5	6.0	6.98	6.91	7.31
Net kilowatts used by compressor	18.91	17.32	18.1	19.5	22.62	22.35	23.69
Brake horsepower used by compressor	25.32	23.20	24.25	26.13	30.31	29.94	31.74
Net kilowatts delivered to line	48.09	65.98	113.9	154.0	177.78	183.4	225.31
Net effective horsepower	64.44	88.41	152.62	206.36	238.22	245.75	301.91
Generator efficiency, per cent. manufacturer's rating	87.0	88.0	89.0	90.0	91.0	91.3	91.0
Net brake horsepower	74.0	100.4	171.4	229.2	261.7	269.4	331.7
Revolutions of engine per minute	174.7	174.1	173.13	173.1	172.9	171.9	171.0
Fuel oil used, pounds per hour	50.0	61.3	81.0	108.0	120.4	128.0	167.0
Pounds oil per kilowatt-hour	1.04	0.93	0.71	0.7	0.68	0.7	0.74
Gallons oil per 100 kilowatt-hours	14.22	12.73	9.73	9.6	9.27	9.55	10.15
Pounds of oil per brake horsepower-hour	0.67	0.61	0.472	0.47	0.46	0.476	0.503
Gallons of oil per 100 brake horsepower-hours	9.18	8.36	6.47	6.44	6.3	6.51	6.9
B.t.u. per brake horsepower-hour	12,829.0	11,680.0	9,038.0	9,000.0	8,808.0	9,115.0	9,632.0
Thermal efficiency of engine $\frac{2545}{\text{B.t.u. per b.h.p.}}$	19.8	21.7	28.15	28.27	28.9	28.0	26.4
Fuel cost of 100 kilowatt-hours in cents oil at 2 cents per gallon	28.44	25.46	19.46	19.2	18.54	19.1	20.3

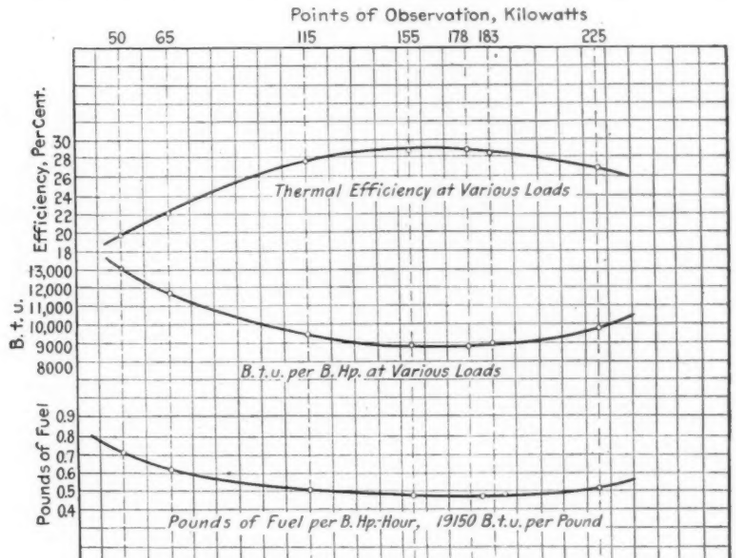

Points of Observation, Kilowatts
50 65 115 155 178 183 225
Efficiency, Per Cent.
Thermal Efficiency at Various Loads
B.t.u.
B.t.u. per B. Hp. at Various Loads
Pounds of Fuel
Pounds of Fuel per B. Hp.-Hour, 19150 B.t.u. per Pound
50 75 100 125 150 175 200 225 250 275 300 325 350
Brake-Horsepower
POWER

FIG. 2. CHART OF PRINCIPAL RESULTS OF TESTS

LETTER

Mr. Parmely's Looped Indicator Diagram

The indicator diagram in Fig. 1 has appeared in POWER twice with ingenious explanations of the loop. Mr. Parmely, who gave the diagram originally, thought that the cause was that the ignition was extremely late and the jacket water cooled the gas, decreasing the volume (and therefore the pressure) of the gas until ignition had occurred. That late ignition does not produce a noticeable loop from this cause is shown by Fig. 2, which was also taken from a producer-gas engine with ignition delayed as far as possible.

Mr. Austin (October 24 issue) explains the loop on the preignition hypothesis. My experience with gas-engine diagrams showing preignition leads me to believe that a compression curve during which preignition occurs always has three distinct parts, as shown in Fig. 3; first, the regular compression curve *C*, to the point of ignition; second, a sharply rising part *E*, during combustion, and, third, a smooth compression curve *F*, of the hot gases. As Mr. Parmely's diagram has a continuously smooth compression

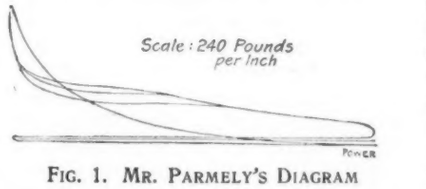


FIG. 1. MR. PARMELY'S DIAGRAM

FIG. 2.

curve, I must differ with Mr. Austin. Besides, the definite combustion lines shown would indicate that the mixture had not been previously burned during compression.

I should say that the loop in the diagram was caused by a defective reducing motion whereby the indicator drum was lagging behind the piston. When the piston was at the end of its stroke, the drum still had some distance to go; as a consequence, the expanding charge decreased in pressure while the drum finished its stroke. This can be plainly seen by looking at the diagram closely. Had the reducing motion been in synchronism with the piston, the expansion line would have followed the compression curve on the return and the combustion lines would have appeared much later in the stroke, as was to be expected with a spark 10 degrees after dead center on an engine using producer gas.

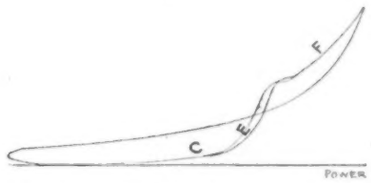


FIG. 3.

Fig. 3 was taken from a two-cylinder engine using artificial gas, the other cylinder carrying the load and preventing the engine from stopping.

G. W. MUNRO.

La Fayette, Ind.

For the purpose of studying the flow of the more important rivers in Iowa, the State geological survey has recently entered into coöperation with the United States Geological Survey. The possibilities of developing the water power of Iowa have aroused much interest, and the records now being made will be of value not only in planning for the utilization of water power but also in devising measures for preventing floods. The river valleys are subject to severe overflow. The subject of the pollution of the streams by sewage is also becoming increasingly important and in this connection the low-water records are valuable in indicating the allowable degree of such pollution.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Blowoff Valve Burst

When about to blow down a horizontal return-tubular boiler carrying a steam pressure of 120 pounds per square inch, I found that the pipe which led from the bottom of the boiler through the rear boiler-room wall into the cellar, where the blowoff valves were located, was clogged with mud and scale. The boiler was equipped with a circulating pipe, as shown in Fig. 1.

I closed the valve *A* and as the valve *B* was open, I opened the valve *C*. Finding

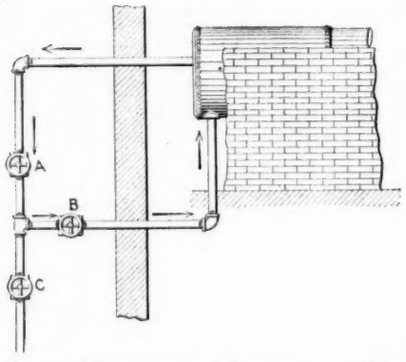


FIG. 1. CONNECTION OF CIRCULATING PIPE

the pipe still clogged, I closed the valve *C*, intending to force city water through the pipes after the day's run. When about to open the valve *A* to restore the circulation if possible, the scale came down with a chug, forcing the crown or bonnet from the valve and badly scalding the upper part of my body.

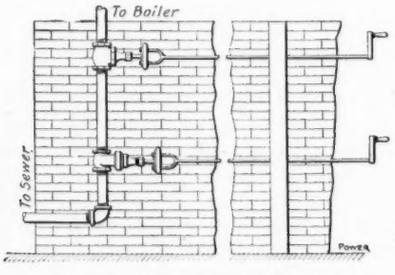


FIG. 2. VALVE-STEM EXTENSION

I had plenty of time at the hospital to plan a different blowoff arrangement and when I recovered I made extension rods, as shown in Fig. 2, each having a crank at the outer end. The other end was made with a Y-fitting which engaged with the handwheel of the valve with a washer and cotter pin placed on the inside of the handwheel.

I think the rods are a good thing as the pipes are not always safe even if the valves are, and while not always practical they can in many cases be used to the absolute safety of the attendant from a painful if not fatal injury.

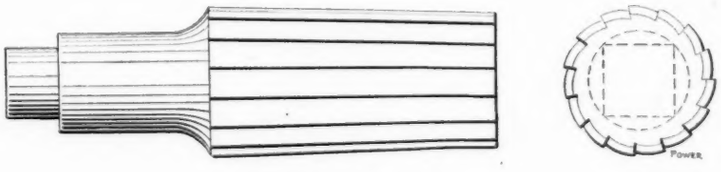
The gate valves do not leak and have given no trouble whatever after five years of hard service.

GEORGE DREWRY.

Brantford, Ont., Can.

An Emergency Reamer

I was running a Corliss engine when the crank pin began to work loose. It was fitted into the crank disk with a slight taper and was held in place by a thin nut on the back side of the crank.



HOMEMADE REAMER

The nut was removed, and when the pin was driven out it was found to be cracked two-thirds of its diameter near the middle of the tapered section. The hole was calipered and found to be true on the back side but was worn nearly 1/32 inch oblong on the front side. A new pin was obtained and an effort made to grind it into a fit.

The job worked well for about a year when evidences of the old trouble began to show itself. I decided to make a reamer, and having no tool steel of sufficient size and being in a rather isolated place, I took a piece of machinery steel and made a reamer as shown in the accompanying sketch. It was case-hardened and served to make a clean, round hole in the crank. A new pin was put in and has been giving good service ever since.

R. S. LIVINGSTON.

Deweyville, Tex.

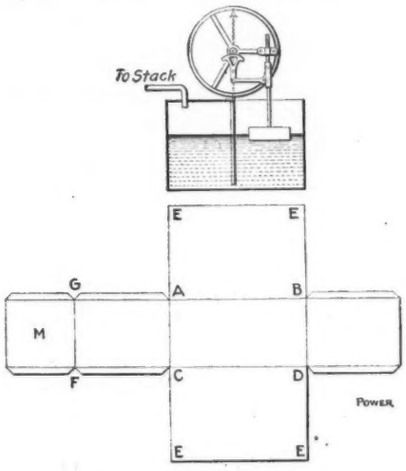
Homemade Draft Gage

In the accompanying sketch plans are shown of a draft gage that most anyone can make out of scraps found about the plant. Take a piece of heavy tin or galvanized iron about 15 inches square and cut it out as shown to make a box 6 and 3 by 4 inches and bevel it on a straightedge through *A B*, *B D*, *C D* and *A C*. Turn down the flaps *M* and securely solder the joints. Then cut a piece to form a middle partition and extend this piece to within ¼ inch of the bottom and solder in place. When this is done turn down the flap on the section *M* and bend through *F G* to form the top of one side of the box. Then solder it to the side and partition. If tight, the box is ready for the U-tube which is connected at one end with the top outside of the closed side of the box. Fasten a piece of ⅛-inch tubing to it for connecting to the stack.

Take the dial, hand and gear from an old steam gage and remove all of the old figures. Then make a support for the dial as shown and fasten it to the back of the dial and the front of the gear frame. Then attach the gear frame to the small pedestal so that the center line of the gear will come upon the center of the box and attach it to the bottom of the gear where the expansion tube was fastened. This extends to the center of the open end of the box, and by means of a link motion connect the lever to the vertical float rod. The longer the levers the better, as they will not have a tendency to bind the rod against the side of the guide as it moves up or down. After the lever and links are attached to the float rod, fill the box with water until the float is a little above the center of the box, and cover it with light, thin oil. Then set the gage hand at the bottom of the dial and calibrate to tenths of an inch by comparing with a standard U-tube. The intervening spaces may be laid off in proportional parts, tenths or twentieths, to suit the individual's fancy. An ordinary 5-inch dial will give a scale

of about 14 inches to each inch of water pressure, making about ⅛ inch to each one-hundredth.

The float will not respond at once to changes of pressure, owing to the large column of liquid that must be moved, but it will be found to be very accurate if there is no friction or lost motion except at or close to zero. The instrument is readily portable as the contents may be poured out at any time and need only



DETAILS OF DRAFT GAGE

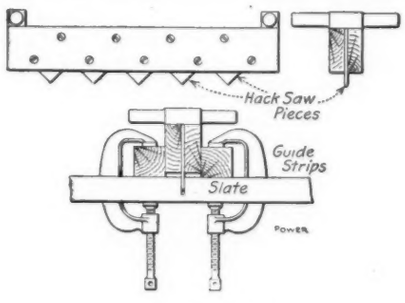
to be set in an approximately level position and filled with water until the hand points to zero to be ready for service again. It may be mounted in a dust-proof wooden case and set up at any convenient point in the boiler room. When nicely finished it makes a very respectable appearance.

E. P. RICE.

Asylum, Miss.

Improvised Slate Saw

The accompanying sketch shows an improvised saw which was used to cut a slate panel for a switchboard. A hack saw was broken into a number of small



SLATE SAW

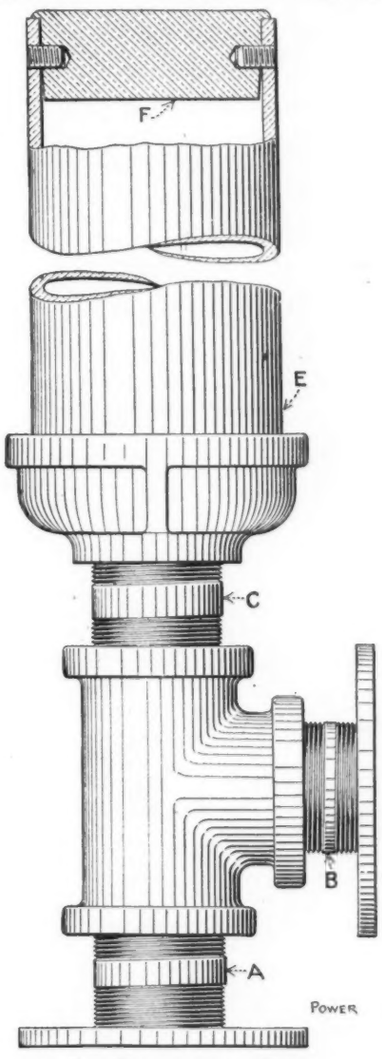
pieces and clamped between two 1x3-inch strips of wood by means of screws. The hack-saw pieces were set to project from the edge of the boards in the form of triangles of about ¾ inch in hight. Two guide strips were held by clamps to the slate panel, as shown, and the saw was worked back and forth between them. Water was used in doing the work of sawing.

J. J. O'BRIEN.

Buffalo, N. Y.

An Emergency Air Chamber

A blow with a sledge hammer, wielded by a discontented laborer, demolished the air chamber of a 10x10-inch duplex, boiler-feed pump and I was called in to "do something." It was impossible to get a new air chamber from the makers, and, after taking a few measurements, I had two 1½-inch steel disks bored and tapped for a 4½-inch pipe and turned up



AIR CHAMBER FOR PUMP

to 10 inches outside diameter. These rings were marked off for the bolt holes from the flanges they were to replace. Meanwhile, three 4½-inch screwed nipples, a 4½-inch tee and a 4½- to 8½-inch reducing nipple were found and fitted together with white-leaded joints, as shown at *A*, *B*, *C* and *E* in the accompanying illustration. A piece of 8½-inch, outside diameter, steel steam pipe was cut off 18 inches long and screwed to fit the large end of the reducing nipple, and was plugged by a brass plug, which was turned with a slight taper. The flanges were drilled for bolt holes and screwed onto the nipples *A* and *B*. The taper plug *F* was calked and burred over with a blunt chisel and a peen hammer, and secured in place by the ¾-inch screws *G*. The air vessel was placed on the pump and connected to the feed line in something under 1½ hours after the job had been commenced. The pump is still running with this air chamber, for a new one has not been ordered yet, and is not likely to be.

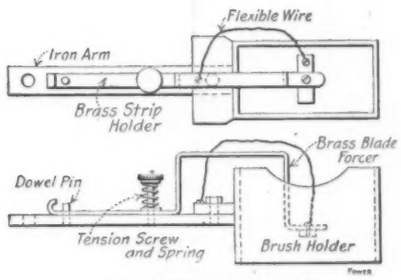
A better job could have been made by screwing a cap over the top of the pipe instead of plugging it, but there was nothing in the stores or about the works to fit.

JOHN S. LEESE.

Manchester, Eng.

Controller Brush Holder

In the accompanying illustration is shown a side view of an arm and brush holder which I have made as a substitute for the old form used on the Morgan chain controller.



NEW BRUSH HOLDER

The old form had two small ears and springs on the sides and as soon as the brush wore down they started to arc and burn off the ears and springs.

The brush holder illustrated herewith has no such delicate pieces to give trouble and will last indefinitely.

E. H. MARZOLF.

Youngstown, O.

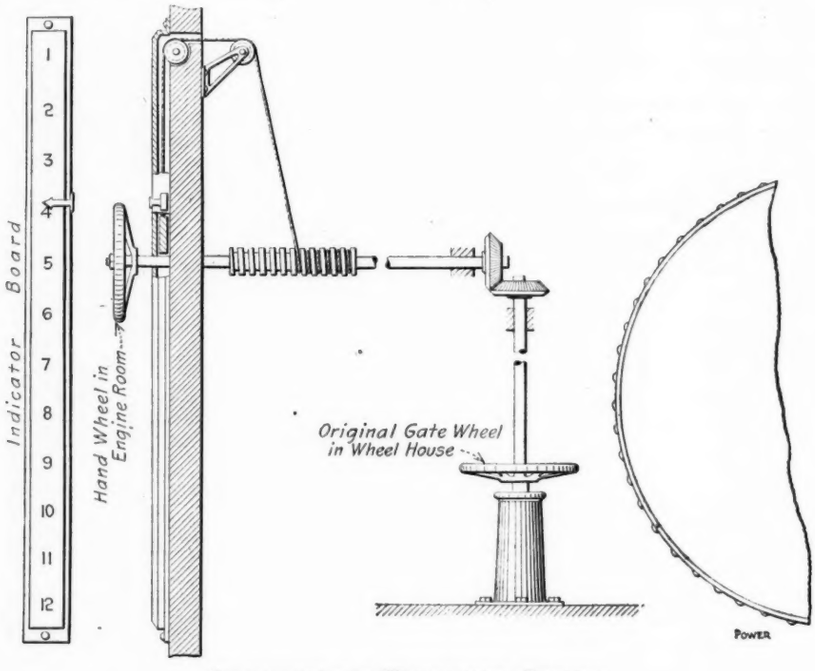
Remote Control of Water Wheel Gate

Several years ago I was employed in a textile mill operated by both steam and water power. The wheel house was at some distance from the engine room and as it fell upon one of the assistant engineers to open and close the gates of the turbines, the engine-room force was handicapped by the loss of a man just at the times he was most needed.

After several unpleasant experiences, it was decided that some method of controlling the turbine gates from the engine room was imperative. The master mechanic easily solved the problem as shown in the accompanying illustration.

The gate wheel in the engine room is mounted on a shaft that is supported by ordinary hangers. On the wheel-house end of the shaft there is a bevel gear that meshes with a gear on a shaft extended up from the original gate-wheel shaft.

In order to tell in the engine room just how much the gates are opened, a graduated board is fastened to the wall beside the gate wheel and an indicator



ARRANGEMENT OF WATERWHEEL CONTROL

finger moves up or down the side of this board when the gate wheel is turned. The indicator finger is attached to a weight concealed in a groove at the back of the gage board and a chain from the weight passes around the gate-wheel shaft in a spiral groove that prevents it from creeping on the shaft.

The figures on the board are cut from calendar pages and glued on evenly. Then the whole board is gone over with shellac. It is difficult to tell that the figures are not nicely painted on, and the result is much more pleasing than if an amateur painted the figures.

This arrangement has proved successful and it can be installed at little expense in almost any plant.

W. L. WHITMARSH.

Phenix, R. I.

Firebrick Arches

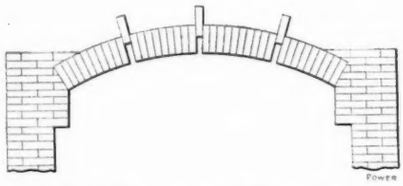
The best firebrick which can be bought are the cheapest to use in building arches. A brick made of good material will glaze over and not break readily, but one of poor material, although it might be perfectly made, will chip, scale and waste away.

The life of an arch depends on three factors: the material entering into its construction; the quality of labor employed, and the temperature of the furnace.

A fourth factor would be whether the furnace is used continuously, for every time the brickwork cools off it will be racked, due to contraction. Firebrick should be kept dry, both before and after installation. One of the best methods of laying brick in arches is to lay them dry, and dipped in thinly mixed fireclay for the side and bridgewalls.

Each row of brick should be gaged to a certain thickness so that there may be no loose brick in the arch, every brick keying up solid.

The illustration shows an igniting arch for a 500-horsepower water-tube boiler fitted with a chain-grate stoker. The key bricks are ready to be driven



KEYS READY TO BE DRIVEN HOME

down, no fireclay having been used. As soon as the keys are driven, a thin wash of clay and salt should be worked into the cracks between the brick, making the arch a solid mass.

Such an arch when made of the best material and properly made will stay up from 10 to 14 months, using the boiler 24 hours per day.

To rebuild the arch, side walls and relieving arch the cost will be as follows:

LABOR AND MATERIALS

580 9-inch bricks at $30 per thousand	$17.40
44 wedge brick at $30 per thousand	1.32
300 pounds fireclay at $3 per ton	0.45
44 hours' labor at 60 cents per hour	26.40
20 hours' labor at 30 cents per hour	6.00
Total	$51.57

A rule I follow is to build all arches dry and later fill in all cracks with salted fireclay. I also gage all brick for the arches so that all rows across the arch are of equal size. I key an arch hard enough to be lifted from off the form when the keys are driven home. I never mix different grades of brick in an arch, but have them all of one grade and manufacture.

I insist on having a perfect skewback, for without a good foundation the result will be a failure.

Brick for side walls and bridgewalls should be dipped in a salted batter of thin clay and be hammered well in place, making as thin a joint as possible.

Bricks, when subject to great heat, expand and provision should be made for this expansion upward by building the relieving arch independent of the main arch.

I always warm up new brickwork slowly and evenly to insure equal expansion and expulsion of moisture.

For estimating purposes on firebrick work I have found that 300 pounds of fireclay will lay 1000 brick when a close joint is made; 85 pounds of fireclay is equal to 1 cubic foot and 1 cubic foot of fireclay brickwork weighs 150 pounds. One cubic foot of brickwork requires 17 nine-inch straight brick, and 1 square foot of 13½-inch wall will require 21 brick. One square foot of 9-inch wall will require 14 brick; 1 square foot of 4½-inch wall will require 7 brick.

FREDERICK L. RAY.

Louisville, Ky.

Repaired Broken Cylinder Head

A certain steam plant had, in addition to the electrical units, a 15-ton refrigerating machine and a piston-valve engine.

One morning the assistant engineer failed to drain the cylinder properly and on starting, as the engine made its backward stroke, it knocked the cylinder head out, smashing it about as shown in the accompanying sketch. I made a steel band ¾ inch wide and ½ inch thick. It was ¼ inch smaller than the head to allow for turning up in a lathe $\frac{3}{16}$ inch smaller than the head. I then filled the cracks with No. 1 Smooth-On, and shrunk the band on the head. After giving it a little time to set, I replaced the head and on starting the engine was somewhat surprised to see that the head did not leak.

When I left the plant a year later, the head was still in service.

D. E. ADEN.

Wilburton, Okla.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Engine Knocks

In the October 3 issue, page 524, W. A. Mills asks for the cause of the knock in the low-pressure cylinder of his tandem-compound engine, which intensifies as the engine picks up its load.

I would advise him to disconnect the crosshead from the connecting rod, having previously marked the limits of travel on the guides. Then push the crosshead to the ends of the guides as far as it will go in either direction. He may find that there is no clearance at the crank end and that the low-pressure piston is striking the head at the end of the stroke.

If there is clearance at each end of the cylinder, there may be such a difference that excessive compression is caused at the crank end. Unequal valve settings will also cause excessive compressions.

If there is nothing wrong with the clearances and valve settings, next examine the valve gear for excessive wear and slackness. This being found right, the cylinder heads should be removed and the piston, junk rings and follower plate examined for looseness.

A prolific cause of mysterious knocks is side play in the piston-ring groove. Examine the cylinder surface for shoulders or ridges which would catch the piston or rings at the stroke end. If nothing is wrong here, Mr. Mills can dismiss the low-pressure cylinder and go over the rest of the engine.

To go through the complete catalog of whys, wherefores and possible causes of engine knocks would fill a complete issue of POWER. Let Mr. Mills look up his back numbers for causes of pounds as they will mostly be found in them. But, just a whisper: Is he overloading the engine?

JOHN S. LEESE.

Manchester, England.

Crosshead Pins

In POWER for September 5, page 371, Lloyd V. Beets brings up the question of the size of crosshead pins. Undoubtedly engine builders have often made these pins much too small, sometimes with a false idea of economy but more often they are small because the engine is sold to work with a higher steam pressure than that for which it was designed. Again, it often happens that an engine of standard design is required to work with a pressure 20 pounds higher than it was designed to work with, and building an engine with larger and stronger parts throughout would make it too costly; therefore the standard engine is sold.

In designing a crosshead pin only the total load on the piston and the limiting pressure per square inch allowable in good practice are known; from these data the diameter of the pin can be obtained from the formulas found in most textbooks.

It is good practice to let the allowable pressure on the pin vary between 1300 and 1400 pounds per square inch; the safe stress on the pin is about 5000 to 6000 pounds per square inch for wrought iron, and from 6500 to 7500 pounds per square inch for steel. If the pressure per square inch on the pin is much in excess of these figures there is the danger of the film of oil between the pin and its brass becoming squeezed out. Should this happen, excessive friction will result and cause rapid wearing of the pin and brass, producing a knock and necessitating the frequent adjustment of which Mr. Beets complains.

As to his statement that the crank pin and the crosshead pin should be of the same size, it will at once be seen that the operating conditions of the two pins are not at all similar; therefore the limiting pressure per square inch would not be the same for both pins; this would cause a difference in the sizes of the pins. As the rubbing surface of the crosshead pin is small and when the composition bearing works against wrought iron or steel, the allowable intensity of pressure per square inch of bearing surface can be high, whereas in the crank pin the velocity of rubbing is much higher and the allowable intensity of pressure per square inch of bearing surface must be lower.

In designing a crank pin the same data as for the crosshead pin are available; that is, the total load on the piston and the limiting pressure per square inch allowable in good practice. The diameter of the pin, if it is overhung, can be found from well known formulas.

Limiting the pressure per square inch from 800 to 900 pounds for engines of slow rotational speeds, is good practice, but for high-speed engines this value should be between 500 and 600 pounds; the safe stress on the pin is about 6000 to 8000 pounds per square inch for wrought iron and 9000 to 12,000 pounds for steel; the length of the pin is usually about 1.4 to 1.5 times its diameter.

If the crank pin is formed in a crank shaft then its diameter is usually the same or slightly larger than the diameter of the main bearings. In this case the strength is ample and the length has only to be obtained from the values of the limiting pressure per square inch.

In an engine designed on these lines for 170 pounds per square inch working pressure, the cylinders being 12 and 20 by 21 inches and arranged in tandem, the crosshead pin is 4 inches in diameter by 6¼ inches long and the crank pin is 5 inches in diameter by 7¼ inches long; thus the difference in the two pins is seen and it is evident that had they been made of equal size either the crank pin would be too small or the crosshead pin too large.

Unless the load is too great, it is usual to put in smaller liners and pistons than the standard for such engines as have to work with a steam pressure higher than that for which they are designed; in this way the reciprocating parts do not have to transmit too great a load; therefore the stresses and pressures are not excessive.

JAMES CANNELL.

Stanford-le-Hope, England.

Engineers' Reference Book

In the issue of October 17, Phil Lighte wants information on starting a reference book. He wishes a pocket-size book of the loose-leaf variety. The one great trouble with books of this description is that they are not made thick enough to hold a great many pages. As material for his book must be filed under the proper headings, and as each heading should have at least a whole page for itself, the book will soon burst with pages, most of which contain very little information. The writer overcomes this with an extra set of index cards and a box to hold them. Anything which is used often is kept in the book, but other material not so important is filed in the box where it may be found when wanted.

Everything read should not be copied. Many articles published, although written in good faith, may not be the best practice.

Everything should be copied carefully, thoroughly; many times I have picked out a formula to use only to be brought up sharply as to whether a certain dimension should be feet or inches.

The great mistake in starting a notebook is to try to copy too much. To copy a long table or the gist of a long article takes time. It may work at the start but as a person's enthusiasm wears off the value of the notebook is apt to deteriorate.

My practice is always to note down the source of the information for future reference in case of any doubt as to the article. If the article is short the whole, or the important part, may be copied. As a rule, an outline of the article, such as is printed in the Hill magazines, is all that goes in the book. If the book or magazine is my own it may always be referred to later, and in any event it may be obtained from a public library.

Occasionally I copy all of some article into my book, but not unless it is of great importance or something that cannot be found in the handbooks. After all, the handbooks contain a good deal of reliable information and are hard to beat.

Many tables that I copied in the first burst of enthusiasm have afterward proved to be common copy matter for the textbooks and catalogs. My advice to Mr. Lighte is to take it easy at first and not overdo it. The scope of the book may easily be increased later if the owner has the time and patience, but do not start off at a pace too swift to hold.

JOHN BAILEY.

Milwaukee, Wis.

Water in Red Hot Boiler

Replying to H. R. Rockwell's questions as to turning cold water into a red-hot boiler, I will relate an incident that occurred with an overheated boiler.

The boiler was 9 feet 6 inches by 30 feet and carried steam at 160 pounds pressure per square inch. One day the boiler got red hot, due to low water. The stoker started the feed pump full speed and had got the water up to the bottom gage cock. The following Sunday the engineer examined the inside of the boiler and found that in each flue the seam just in front of the bridge had a drop in at the top nearly 2 feet long and was depressed about ½ inch.

Disastrous boiler explosions have occurred by allowing the tops of the boiler flues to get red hot and by their becoming bulged in by the pressure inside the boiler. If the cutting in of boilers is carefully done and the pressures in the boilers slowly equalized, there is no danger, but unless this care is taken the operation is very dangerous. It is common practice for a boiler to be opened out on to the main when its pressure is either above or below that in the main, but all steam valves must be opened very cautiously so that the steam pressures in the main and in the boiler will slowly equalize. It is the accumulation of water above the stop valve that forms one of the dangers of opening a boiler stop valve suddenly, and whether the pressures be equal or not there is the danger of the water being driven violently into the boiler or into the steam main. There is a large volume of water in a boiler which is at the same temperature as the steam and if, by rapidly opening the stop valve, the pressure is suddenly reduced, a certain amount of this water becomes instantly converted into steam, and the steam generated at the heating surface of the boiler in endeavoring to escape lifts the water above it and the result is a severe water hammer against the top plates.

The reason the explosion of one boiler causes the others to explode is because the steam in them is suddenly liberated. This reduces the pressure in the boilers, and causes the sudden generation of steam throughout the mass of water, and the generation of such a large volume of steam causes the water above it to be projected with great velocity and energy against the containing walls of the boiler; this water-hammer effect is responsible for the fracturing of the boiler.

If a throttle valve shuts off steam completely and no steam gets into the cylinder, an engine cannot increase its speed and it will eventually stop. An engine runs because there is a difference of pressure on the two sides of its piston, and if there is no leakage of steam into the cylinder the condenser will establish a vacuum on both sides of the piston, it will be in equilibrium, and the engine will stop.

V. E. CLARKE.

Manchester, England.

In reply to Mr. Rockwell's queries in the September 12 issue, I would give the following as my opinion on the first question relating to turning water into a red-hot boiler.

The experiment has been tried several times on this continent and in Europe, but the boilers would not explode. Assume that the boiler is heated to a bright red; as there is no pressure inside, there is nothing to explode the boiler.

If feed water is fed to the boiler the heat in the plate is readily absorbed by the water, which will roll about in a more or less violent manner. The boiler will rapidly cool off, setting up all kinds of strains in so doing, and the probability is that it would be ruined.

H. POWERS.

Montreal, Can.

Retubed the Condenser

With reference to P. P. Fenaun's article in POWER of September 26, relative to the method he employed in taking care of the expansion of the tubes in his surface condenser when it was operating on intermittent loads, I recently visited a power plant having a specially built condenser, designed to handle intermittent loads. As in Mr. Fenaun's plant, there would rarely be a constant load, and it came to the condenser in jerks.

The tubes were expanded into the tube plates at both ends, doing away with all tube packing. One end was arranged with a standard water box, etc., but the other end was arranged with a floating-head. The tubes are expanded into the tube plate at the floating-head end, which rests on the shell and slides backward and forward as the load differs, thus taking care of the expansion and contraction of the tubes.

N. OWITZ.

New York City.

Flywheel Explosion at West Berlin

The editorial in the October 3 issue, entitled "Offhand Verdicts," interested me, especially the term "absent treatment."

As already stated, the chief engineer (who was more than a mile away from the West Berlin plant when the accident occurred) found that the accident was due to No. 1 generator becoming motored by the reversal of the current through it from No. 2 generator, which carried a slightly higher voltage; also, that the circuit-breaker failed to open because the latch had become expanded by abnormal heat.

The theory that the engine was wrecked by the generator to which it was belted becoming motored by the reversal of the current through it from the generator of the other engine may seem plausible at first thought, but the fact that the armature windings were torn loose and in a tangled mass radiating from the center of the shaft explodes that theory because the machine would cease being a motor before reaching that stage of destruction.

The theory is advanced that the circuit-breaker failed to open, owing to the abnormally high atmospheric temperature of a few days preceding, which had expanded the latch. This is offset by the fact that the accident occurred well along after sundown, when the temperature would be such as to contract the parts of the circuit-breaker to their normal size.

The plant was erected less than 13 years ago, and I have often seen one engine furnishing all the power required.

I was the author of the first account of the accident published in POWER and wrote the account, thinking the matter would be of interest to the engineering fraternity. No thought of censuring anybody entered my mind, because from the "jolts" received during many years of experience with machinery I do not consider any mechanical device infallible.

I still hold to the same opinion expressed in my first article, for what I saw at the plant before and since the accident leads me to believe that the trouble was caused by the governor belts running off the pulley.

J. W. PARKER.

Clinton, Mass.

To Prevent Standpipe Freezing

Replying to Thomas Nicholson's question, I would suggest that he keep the surface of the water in continuous motion in the standpipe during cold weather by allowing a stream of water to fall upon it.

A covering, say 6 inches thick, of common straw all around the standpipe is sufficient to prevent the water from falling below the freezing temperature. The straw should be held in place by thin boarding, covered on the outside by tar paper. A less thickness of straw may be sufficient, but this would depend upon the exposure of the standpipe.

JOHN ZETTERLUND.

Eskilstuna, Sweden.

Massachusetts License Laws and Examiners

The letter by C. C. Harris, in the issue of October 10, contains some excellent ideas regarding the Massachusetts license laws, but he is mistaken in thinking that special licenses apply only to second-class plants and below, as the law only says that special licenses shall not be given to one who is to have charge of plants of over 150 horsepower, and many first-class plants are operated by holders of special licenses. Why should it be necessary to limit these licenses to six months, or any other specified time, as recommended by Mr. Harris?

Suppose, for illustration, that an engineer is running a small plant consisting of a horizontal tubular boiler and a 60-horsepower slide-valve engine, with the usual pump, etc. Being over 50 horsepower, this would require either a special or a second-class engineers' license. Having been examined and found competent to care for all parts of the outfit, he is given a special license to have charge of and operate this particular plant, and in all probability he is capable of meeting any emergency which may arise in connection with its operation.

Why does Mr. Harris believe it necessary for the protection of the public that this man should within six months pass an examination covering all types of engines, boilers, pumps and other appliances found in any plant of 150 horsepower or under, to say nothing of the "impractical" questions which we are told form a part of every examination?

Failing in this, he would be obliged to give up his position.

Personally, I know men who have operated first-class plants on special licenses for a dozen years without causing either inconvenience or danger to the public.

ROY W. LYMAN.

Ware, Mass.

In this discussion there should be no confusion of the merits and imperfections of the law with its administration by the inspectors. If the inspectors make mistakes, that is not the fault of the law, and to argue against the law on that basis, as is sometimes done, is hardly logical. I believe the law is a good one, but not yet ideal.

Mr. Harris says there are many engineers who would like to change the law and abolish the special license. This would seem to be an amendment in the right line. But Mr. Harris and the many others ought to know that kicking and growling about this thing in the boiler room will be of no avail. If these men want the special license done away with, why not go at it?

As for the inspectors, they are human beings and therefore liable to error; but I know they are subject to wilful misrepresentation, and that thereby their errors are magnified and multiplied. I know of cases where men lied about their examinations—reporting questions and conversations which never occurred. When a man comes back rejected, take his story with a grain of salt.

Mr. Harris thinks the examination should be wholly practical. Possibly his picture of an engineer is a man who can open and shut valves, squirt oil and shovel coal; but the engineer of that type is a back number. In every trade today the requirement is for a man who knows the underlying principles of the practice, who uses his brains and who understands the relation of his work to that of others. This is especially true of the stationary engineer. He ought to know boiler design, not because he has to design boilers, but because he ought to know that his boilers are designed correctly; and he ought not to have to wait for an inspector to come along and point out the faults.

A new plant just installed in Boston has boilers designed for 180 pounds pressure. The law requires two valves with a drain between them upon boilers allowed over 135 pounds pressure per square inch. This plant was installed with only one valve per boiler. A wide-awake engineer would have seen this fault and have pointed it out in time; but in this case the boiler inspector was the first to notice it. Most engineers have seen serious mistakes in piping, in foundations and in other items about the plant, mistakes made by the designer and left for the engineer to rectify. The correction of these mistakes often calls for keen intelligence and broad knowledge. The "practical" rule-of-thumb man is not able to meet the occasion. In fact, the only man who is practical in the best sense of the word is the man who squares his practice with uptodate science. For this reason the inspectors are perfectly right in examining applicants upon "theoretical matters."

Another claim that, at first thought, might seem plausible, is that examinations should be confined to matters of safety. Upon second thought, most of us will probably reject this, but suppose we do not consider the matter carefully and safety turns out to be not such a simple matter, after all. Disaster comes in new and unexpected ways. Witness the recent accident at West Berlin where a generator motored and burst its flywheel. A few months ago an examiner would probably have been severely criticized had he asked questions concerning the parallel operation of generators or the care of circuit-breakers. And yet, in the light of what has happened, it seems that merely on the ground of safety, knowledge of such matters ought to be required of applicants for second- and first-class licenses. Because no one was killed at West Berlin is no reason why we should not heed the warning. There are other plants where the same thing may happen at any minute.

No man who does things without knowing why is really a safe man. Unless he knows the theory of the operation he may do very dangerous things. Receiver pressure and its regulation might be considered theoretical questions, yet there is at least one engine running in a dangerous condition because a "practical" engineer tried to adjust the receiver pressure by lengthening the governor rod to the high-pressure valve gear.

One regular examination question is, "How does a pump lift water?" It is a temptation to class that as a theoretical question in no way related to safety. Yet not until one understands the principles underlying this action can he understand how an engine cylinder can take water from the exhaust pipe and smash things up. When it is recalled that one engineer smashed three engines in 15 minutes in this way, it is seen how vital this question is in relation to safety.

Steam engineering is by no means on the perfection level. It is going up and rapidly, too. As it goes, new problems are being opened up, many of them relating to safety. The man who is content to plod along the way grandpa did, is hardly a safe man. A safe man will not

be found putting cast-iron valves and fittings in lines carrying superheated steam. He regards water hammer as one of the most serious dangers in a plant and will carefully avoid it in every way.

Mr. Harris furnishes an amusing instance of inconsistency when in one column he condemns the orders to "stiffen up" the examination and in the next complains that certain engineers are running plants "on the ragged edge." Worse cases than that are not hard to find, Mr. Harris. A certain holder of a first-class license cannot read an indicator card, and when told that the card showed his Corliss engine had too much compression he was at a loss as to how to remedy it. There is another engineer who actually does not know the difference between a primary heater and the receiver of a compound engine—and worse yet might be told, only it would seem unbelievable. There are first- and second-class engineers who are satisfied with jobs as firemen—a tacit admission of their own incapacity.

The orders to "stiffen up" were needed. Mr. Harris wonders who gave the orders. I will tell him: It was Common Sense.

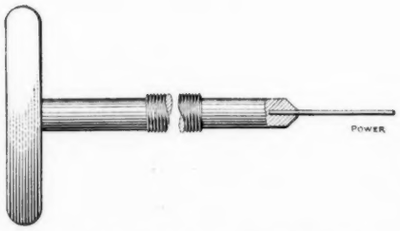
WILLIAM E. DIXON.

Malden, Mass.

Wire in Sight Glass

In the October 17 issue, page 598, is a letter by Mr. Sobolewski, showing how he placed a wire in the sight glass of a lubricator, thus causing the oil to run up to the top of the wire, thereby keeping the glass clean.

I have had the same trouble with the sight glass of a lubricator on a steam pump. The oil would flow over the side



WIRE IN END OF NEEDLE VALVE

of the nozzle and cling to the glass, sometimes filling it.

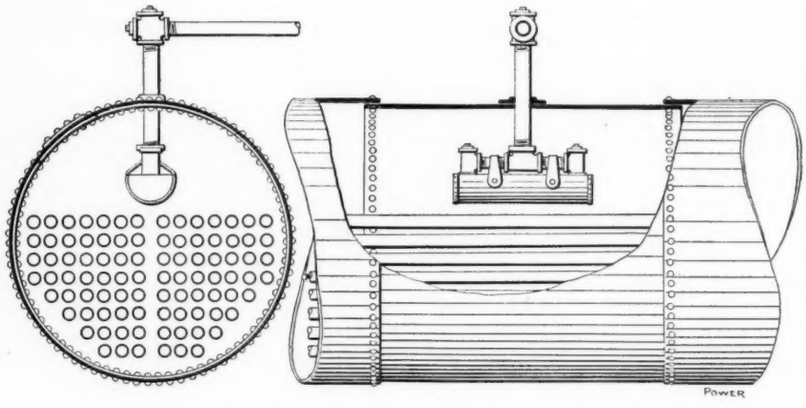
To overcome this trouble I flattened the point of the valve slightly and drilled a small hole about $\frac{3}{16}$ inch deep and then inserted a wire as shown in the accompanying sketch. The end of the wire was soldered in the point of the valve stem and was made long enough to project a little above the top of the nozzle.

FREDERICK L. JOHNSON.

Paterson, N. J.

Trouble with Leaking Tubes

In the September 5 issue, under the caption "Trouble with Leaking Tubes," William Beaton gives Mr. Reimers some very good advice as to the prevention of leaking tubes. Having had the same trouble as Mr. Beaton and having overcome it by changing the position of the feed-water inlet, I quite agree with Mr. Beaton's statements.



SCALE COLLECTOR ATTACHED TO END OF FEED PIPE

However, I think I have an improved method of delivering the feed water. It is discharged into a cast-iron trough which is suspended above the tubes, The accompanying sketch makes the arrangement clear. The piping inside of the boiler is made up of tees, nipples and plugs. This trough gathers a large amount of scale and needs to be removed and cleaned when cleaning the boiler.

CHARLES FENWICK.

Wapella, Sask., Can.

Direction of Compressor Rotation

In the issue of October 24, page 642, A. E. Peterson mixes me up rather than otherwise. I saw one of the earliest Corliss engines—about 1855, I think—and its running under astonished me about as much as if I had seen a clock running backward. It has always been understood, I believe, that steam engines are run under to relieve the crosshead and guides of some of their pressure and wear by a difference of weight equal to double that of the crosshead and the connected ends of the rods. Mr. Peterson seems to assume that it is desirable to keep all the pressure downward.

In the case of the direct steam-driven air compressor the argument works both ways in either case, and there will be a transfer of pressure from downward to upward, or *vice versa*, in every stroke. If the compressor runs over, the pressure is downward for the first half of the stroke, but in the latter part of the stroke the air resistance is greater than the steam pressure, and the flywheel to help the running makes a pull on the connecting rod or a lift on the crosshead.

If the compressor runs under, the crosshead is lifted for the first part of the stroke, but at the other end of the stroke the pressure is downward and there is little to choose, either way. In the belt-driven compressor the crosshead pressure will be downward for the whole of both strokes if the compressor is run under, and the pressure will be upward if it is run over.

FRANK RICHARDS.

New York City.

Setscrew Came Loose

Mr. Stewart's article in a previous issue of POWER on safety stops brings to mind an experience I had with a 750-horsepower Corliss engine when the setscrew worked loose in the governor pulley. It did not allow the governor to entirely stop as the friction of the pulley on the shaft maintained enough speed to prevent the safety cams from being disengaged from the hooks, but the speed was not enough to maintain a proper cutoff.

I was standing within 20 feet of the engine when the valve hooked up, and by the time I got the throttle valve closed the engine was going in the neighborhood of 200 revolutions per minute, which did not look good for an 18-foot flywheel.

J. W. DICKSON.

Memphis, Tenn.

"We have reached our present high standard of operating efficiency," says S. G. Pollard, superintendent of operation at the Cincinnati waterworks, "simply by taking advantage of the conditions of our service, by putting and keeping our plant in the very best condition and by looking after all of the details of operation, none of which is too small to merit careful attention."

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POWER

Oil in Exhaust Steam

There are comparatively few steam-power plants where an economy cannot be effected by returning the condensation from the feed-water heaters or surface condensers to the boilers.

This is particularly true where the feed water is bought instead of being drawn from wells, streams or ponds, for besides the heat conserved by using the warmer water from the drips or hot-well, the cost of the water itself is saved.

But there is, in those instances where no provisions have been made for the separation of the oil from the condensation, danger in its use for boiler feed. There is practically no danger from the oil as long as it remains oil, but this is not for a great while after it gets into the boiler.

Several things happen to it then. Subject to long-continued heat, a part of it is distilled, leaving behind a sort of tar which readily gathers to itself some of the loose scale-making matter in the water and thus becoming heavier than the water, it settles to the bottom of the boiler where it attaches itself to the sheet as soon as the water becomes quiet.

Wherever this mixture of tar and scale touches the metal it adheres closely, preventing the access of water and, if over the fire, a burned sheet or tube is certain.

Sometimes the oil enters the boiler in the form of an emulsion which acts like a varnish to the inner surface of the boiler, preventing actual contact between the metal and the water. In its first stages this varnish is so thin that it offers little resistance to the transmission of heat to the water, but it soon grows to a thickness that makes the bagging of the boiler a certainty.

If the oil in the exhaust steam is thoroughly separated from the condensation which is returned to the boiler as feed water, it will result in a great saving in water as all that will be needed beyond condensation will be the small percentage of makeup required to replace that lost through leakage. As the condensation will be considerably warmer than the water from wells, ponds or city mains, there will be a saving of the amount of fuel necessary to make up for the difference in the temperature of the water.

Incidentally, there will be another saving which, while of great importance, is not so readily measured. Freed from oil and scale-making impurities, all trouble and expense resulting from scale, foaming, leaking tubes, burned and bagged shell plates and tubes will disappear and the necessity for frequent inspection and cleaning will be avoided.

It sometimes happens that the regular water supply is shut off for hours at a time, causing great annoyance unless there is some form of tank or reservoir used in connection with the feed-water system, but with an efficient method of separation such a tank will permit the shutting off of the regular supply for several times the duration possible without the separator.

Surface Combustion

Attention is called to the interesting demonstrations by Professor Bone, described on page 767. The mode of combustion there exemplified has been applied to several industrial operations, including steam making; a nine-foot boiler, about which we hope soon to have more extended information, being in successful operation in the Yorkshire district of England.

It is interesting to recall that Dr. Charles E. Lucke, of Columbia University, described practically the same process in a paper entitled "Liquid Fuel Combustion," presented to the American Society of Mechanical Engineers at its spring meeting in 1902. He called it "explosive combustion." He was searching for a process whereby liquid fuel might be burned under pressure in order that the products of combustion might be used in an engine. The gasified fuel, with the requisite quantity of air for combustion, thus forming an explosive mixture, was introduced into the small end of a funnel and ignited in the cone-shaped portion. The flame took the shape of a section of a spherical surface, but did not fill the section of the funnel, and increasing the velocity of the entering gases only carried the flame farther into the cone. It was a natural step to throw in a handful of refractory material to break the flame up and the flameless combustion demonstrated by Professor Bone was produced. Later experiments developed the fact that the shape of the chamber was immaterial and led to the introduction of the explosive mixture of gas and air into a mass of broken refractory material, as Professor Bone does in his steam boiler and muffler. The process evidently has some

possibilities in connection with the continuous internal-combustion engine problem upon which Doctor Lucke was experimenting.

Expert Advice

The managers or owners of an important project in the power-plant field do not hesitate to engage a competent consulting engineer to advise and assist them with the plans and specifications and to inspect the work and materials when they have no man of sufficient attainments upon their own staff. The reputable power-plant engineer is likely to be entirely unbiased except by the reasonable desires of his client, and his broad experience enables him to show the adaptability or unfitness of any piece of equipment to the exact needs of the work in hand. He is not likely to be influenced by the extravagant claims of unscrupulous or too eager salesmen. He is able to execute the plans in a satisfactory manner, and to so write the specifications that his client shall be protected from an inferior article both in material and workmanship. His knowledge of contract law should enable him to protect his client from an expensive and avoidable encounter in the courts. His intimate knowledge of the honesty, reputation and reliability of the various contracting firms should enable him to select those firms which are able to do the work or to furnish the best equipment. He is prepared to conduct the acceptance tests with perfect fairness to all concerned. He is, furthermore, able to protect the contractor from his client's hasty or ill-advised actions, and thus save grief for both the client and the contractor.

The relations between the owner, the engineer and the contractor should be fully and definitely understood by all, and it is the first duty of the engineer to make sure that they are understood. In some cases the engineers are a corporate part of the holding company, in which event there is little to be said. In the general case, however, where the owner selects a reputable consulting engineer, the first procedure should be to carefully prescribe the services which are to be performed.

It is unwise for the engineer to promise to serve in any capacity but that of adviser; that is, his reports should be of facts and his actions should take the form of recommendations only. Here his authority ends and he is not justified in taking any arbitrary action not previously specifically prescribed unless such action is immediately necessary for the best interests of his client; then the engineer should immediately inform the owner of the action taken together with the reasons therefor. It is not only the duty of the engineer to prepare the plans and specifications, but he should be ready to instruct the owner as to the reasons for his policies should the owner so desire. The fullest and freest consultation is advisable in all cases so that the mutual understanding shall be complete. The owner should then invite the opinions of his operating engineers and present them to his consulting engineer for his consideration.

It is the duty of the engineer to fairly and firmly inspect the work and materials furnished by the contractor to make sure that they comply with the requirements and with the intent of the specifications. It is a mistake to arbitrarily enforce requirements which are obviously unfair or unreasonable, and a contracting firm should refuse to bid on specifications which contain requirements which would work a hardship upon it. Notwithstanding these facts, it sometimes happens that clauses which admit of unfair interpreaation are inadvertently included in the specifications. It is then the duty of the engineer to read the intent of the specifications rather than the letter.

The owner must expect some disappointments; the most carefully executed plans of the most competent engineers are liable to result in minor disappointments. No two men will agree upon a perfect result. Human labor merely approximates a perfect standard and, in an intricately complicated structure, such as a power plant, it is practically impossible for any man to completely foresee the end from the beginning. The owner has, however, by employing a competent engineer, insured himself against a failure of his intentions; he has saved himself time, expense and an infinite amount of trouble; he has secured the best results obtainable under similar conditions for an equal outlay.

Many manufacturers of power-plant equipment place their consulting departments at the command of anyone who is in the market for equipment. No charge is made for this service, the expense being assigned to the effort to make a sale. Usually no attempt is made to displace the consulting engineer, as the free advice is offered to and accepted by those who would not ordinarily employ a consulting engineer.

The results obtained by this arrangement are not, in all cases, entirely satisfactory. Naturally the opinions offered and the type of equipment advised would be favorable to the firm giving the advice. In the case of an open-market purchase this would work no particular harm, but it would be manifestly unfair to other bidders should the job be let by contract. There is also danger on the manufacturer's side that, owing to the extreme eagerness to make a sale, equipment may be advised, purchased and installed to do work for which it is not properly fitted. The result will be failure and disappointment. Advice which is valuable is worth paying for.

Modern Tendencies

It is significant of the present trend of thought among users of power equipment that during recent conventions of engineers and operating men the papers presented on this subject have been mainly from the standpoint of safety, reliability and permanence of investment; points which were emphasized in the ensuing discussions. The terms "efficiency" and "economy," which have ordinarily been very loosely used, were also more sharply defined; and speakers found it necessary to make precise statements on these points, as interruptions and queries were otherwise certain.

In this connection much interest was displayed in any account of the changing over to a new power system or the rearrangement of an existing plant to secure better service. Auditors wanted to know just what steps had been taken to determine the exact gain to be expected from the change, what allowance had been made for expansion and how the probable useful life of the new apparatus had been determined; whether it was expected to retain and add to this as the requirements of the service were extended, or to discard it, after a certain lapse of time, in favor of equipment then developed which would show still greater economy.

For the most part, the tendency seemed to be to make plans on the "unit" system, with the expectation that power machinery now being provided will continue in service for a considerable period, serving toward the end as a reserve possibly, but still retaining its usefulness.

It appears to have been felt by many of those attending conventions that the limits of engine and turbine steam economy, except as this may be improved by further gains in the efficiency of condensers and other auxiliary apparatus, have practically been reached, unless there are developments now wholly unforeseen. Therefore, equipment installed during the near future may reasonably be regarded from the standpoint of permanent investment and the selection of the various machines governed accordingly.

How far this theory dovetails with the facts only the future can determine. The steam field is not without recent inventions, particularly in Germany, which may yet revolutionize some features of power-plant practice.

For extensions of economy beyond that of single machines, the low-pressure turbine unquestionably offers great opportunities; but no power user should allow himself to be carried away with the idea that this provides a certain means of getting something for nothing. There are conditions under which it is a paying proposition and others where it is not. Hence, the matter ought, in all cases, to be carefully gone into in advance.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Steam Consumption of Duplex Pump

What is the steam consumption of a duplex pump with a steam cylinder of 12 inches diameter; water plunger, 8½ inches; stroke, 10 inches, when pumping 500 gallons per minute, steam pressure 100 pounds, against a head of 110 feet, static and friction?

P. S. D.

In first-class condition and working at a fairly high rate of piston speed, a duplex pump may develop a horsepower on 100 pounds of steam per hour; while with a low piston speed and in an average state of repair, the water rate may easily be more than double this.

To pump 500 gallons of water per minute against a total head of 110 feet requires about 14 horsepower.

If the mechanical efficiency of the pump is 80 per cent., the horsepower delivered to the steam cylinder to produce this will be

$$14 \times 1.25 = 17.5 \text{ } \textit{horsepower}$$

and for an efficiency of 60 per cent. it will be

$$14 \times 1.66 = 22.33 \text{ } \textit{horsepower}$$

At 100 pounds of steam per horsepower per hour the steam consumption will be 1750 to 2233 pounds per hour, depending on the efficiency of the pump.

Receiver Pressure

An engine, 20 and 40 by 42 inches, is to be started. Assuming that a 24-inch vacuum will be attained in the condenser, and a boiler pressure of 125 pounds, gage, what will be the right receiver pressure and how is it to be found?

F. C. H.

The object of compounding is twofold, to distribute the load between the cylinder for mechanical considerations and to reduce the loss from cylinder condensation by dividing the temperature range.

The temperature of 125-pound steam (140 absolute) is 353 degrees. The temperature corresponding to a 24-inch vacuum is 141 degrees. The range is

$$353 - 141 = 212 \text{ } \textit{degrees}$$

If the temperature drop one-half of this, or 106 degrees, in the high-pressure cylinder, the temperature of the receiver will be

$$353 - 106 = 247 \text{ } \textit{degrees}$$

corresponding to a pressure of 28.37 pounds absolute, or 13.67 pounds gage.

To divide the load equally the receiver pressure should be 24.5 pounds absolute. Directions and tables for calculating this were given in POWER for July 18, 1911, page 88. Clearance, wire drawing and compression would modify this somewhat.

Carbon Dioxide in Flue Gases

An account of the "High Duty Performance at the Cincinnati Waterworks" states that the flue-gas analyses show from 10.5 to 11.7 per cent. of carbon dioxide out of a possible 12.2 per cent.

The statement is something entirely new to me inasmuch as I always supposed that with perfect combustion the percentage of carbon dioxide was nearly 21.

Will you give an explanation why it would be possible to obtain only the 12.2 per cent.?

D. C. G.

Natural gas was the fuel used in the test of the pumping engines conducted at Cincinnati and the products of combustion would, of course, be different from those where coal was used. If hydrogen gas had been burned under the boilers, the possible and actual percentage of CO_2 would have been zero.

Heating Surface of Corrugated Flue

How is the heating surface of a corrugated furnace flue calculated?

W. E. O.

Find the average diameter by adding together that of the top and the bottom of one corrugation in feet and dividing the sum by 2. Multiply this by the length of the flue in feet and by 4.93. This will give the entire surface in square feet. That portion of the flue above the grate will be the heating surface and will be such a proportion of the whole surface as the portion of the circumference above the grate is of the whole circumference.

Air Lift Calculations

In an air lift to deliver 200 gallons of water per minute at a hight of 130 feet, what should be the diameter of the water and air pipes and the air pressure?

J. A. W.

To deliver 200 gallons of water per minute at a hight of 130 feet above the surface of the water in the well will require a 3½-inch pipe submerged 260 feet. The diameter of the pipe should be uniform throughout its length.

The air pipe should be 1¼ inches in diameter with the lower end simply turned upward inside the lower end of the water pipe.

It will require about 175 pounds air pressure per square inch to start to lift and about 130 pounds pressure for continuous operation.

Steam Pressure and Temperature

In POWER for May 16, page 783, under "Steam and Air Pressure," it is stated that air at 110 pounds will force steam back to the boiler and increase its pressure to that of the air. Is it a fact that steam in the presence of water can be compressed to a pressure higher than the temperature of the water from which it was generated?

S. S. H.

Steam may exist at pressures higher than that due to the temperature of the confining medium, just as ice may exist in water warmer than the ice.

Steam is warmer than the cylinder of the engine it enters and may be compressed in a boiler to a pressure higher than that due to the temperature of the water from which it is made.

Authority on Boiler Repairs

Please tell me where I can find descriptions of boiler patching by an undisputed authority.

W. R. S.

Patching is a class of repair work on which there can be no undisputed authority, as conditions vary in every individual case. Only good mechanical common sense is of value in this kind of work.

At the River pumping station the Cincinnati waterworks have four 30,000,000-gallon pumping engines operating against a variable head of from 101 to 139 feet. Nut and slack bituminous coal was used to obtain, in an average duty for nine months, 120,376,000 foot-pounds per 100 pounds of coal, with but two engines in operation.

Heating and Ventilation

Considered as power plant problems. Layout and operation of systems and apparatus

Heating and Ventilating a Factory

By John S. Nicholl

In every respect the factory of Brewster & Co., Long Island City, designed by Stephenson & Wheeler, of New York City, is an example of modern factory-building construction. Instead of having a plain exterior, the appearance of this six-story structure, surmounted by a large tower, is not unlike a convention hall. It is evident that much attention has been given to the consideration of the comfort of the occupants. The heating and ventilating system includes arrangements for cleansing and humidifying of the air by Webster air washers.

Three systems make up the heating and ventilating plant, though practically the entire building is heated by the fan system. In certain quarters on the second and sixth floors, additional radiation service is secured from a one-pipe system. A two-pipe system of domestic steam supply is provided for certain domestic steam radiation, including glue heaters, steam boxes and kettles. The main-office vestibule is taken care of by an indirect heater suspended from the basement ceiling immediately below, this heater being incased in galvanized-iron ducts that connect to the main-supply air ducts. For heating the tower and the tank house on the roof, there are radiators connected with the one-pipe system.

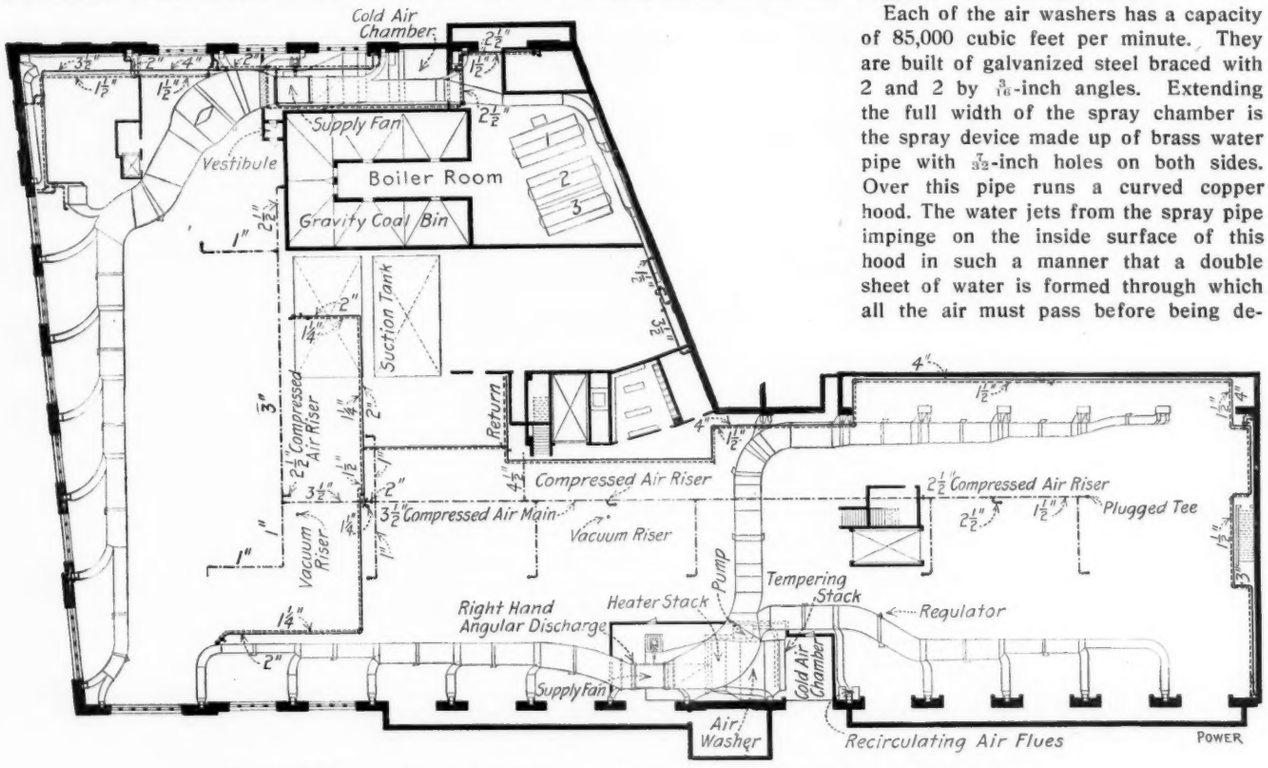


Fig. 1. Plan of Brewster Factory, Showing Heating and Ventilating System

Situated in opposite sides of the basement are two sets of apparatus, making up the fan system. Each of these supplies to half of the building properly cleansed and humidified fresh, warm air. Each group consists of a tempering coil, air washer, reheater and a fan, driven by a direct-connected vertical steam engine. Inasmuch as the only difference in these sets is that one fan is a right-hand top horizontal and left-hand bottom discharge, while the other is the reverse, the same description applies to both.

The fresh-air intakes for the fans are made of copper capped with a storm-proof hood and furnished with fine-mesh copper screens and dampers. Leaving the fresh-air chamber the air passes over the tempering coils made up of 2448 square feet of American Radiator Company's "Vento" radiated surface and then enters the air wahser. From this point it is drawn through the reheater of 6120 square feet of "Vento" radiated surface and distributed by the fan to the two main ducts, from whence it is supplied to the various floors.

Each of the air washers has a capacity of 85,000 cubic feet per minute. They are built of galvanized steel braced with 2 and 2 by $\frac{3}{16}$-inch angles. Extending the full width of the spray chamber is the spray device made up of brass water pipe with $\frac{7}{32}$-inch holes on both sides. Over this pipe runs a curved copper hood. The water jets from the spray pipe impinge on the inside surface of this hood in such a manner that a double sheet of water is formed through which all the air must pass before being delivered to the building. Falling into a tank below, the spray water is recirculated by a turbine pump direct-connected to a motor. After leaving the air washer, the air is drawn over the reheater and then forced to the various parts of the building. The inlets of the fans are 68 inches, the discharge being horizontal at the top and annular at the bottom. The 12x10-inch vertical inclosed self-oiling steam engine is capable of driving them at 250 revolutions per minute. A Powers system of temperature control is used in connection with the

tempering and reheating stacks. This is accomplished by a cold-air thermostat operated at 38 to 40 degrees Fahrenheit in such a manner as to guard the air washer against freezing. If the temperature of the entering air falls below 38 degrees Fahrenheit the tempering coils receive steam, the thermostat being connected to the supply and return valve of the individual groups of the tempering coils. In connection with this system there is an automatic electric air compressor with a suitable storage tank, automatic governor, indicating gage, etc.

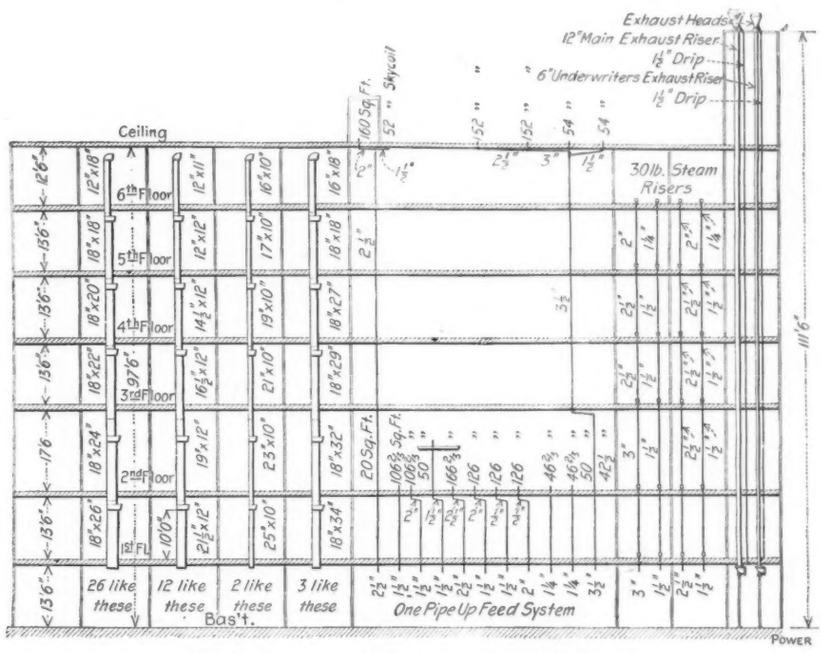


FIG. 2. VERTICAL SECTION THROUGH BUILDING

The tempering stack is made up of two groups of 60-inch "Vento" cast-iron radiators, each group being 36 sections wide and three sections high. The reheating stack is similar to this, with the exception that it is five groups deep instead of two. Steam is supplied to all the systems by three 150-horsepower Heine boilers located in the basement. The working pressure carried is 150 pounds. A reducing valve permits of the domestic steam system using a pressure of 30 pounds. The exhaust from the fan engine is used in the heating system and supplemented by live steam where necessary.

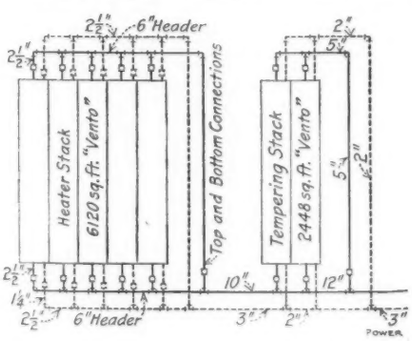
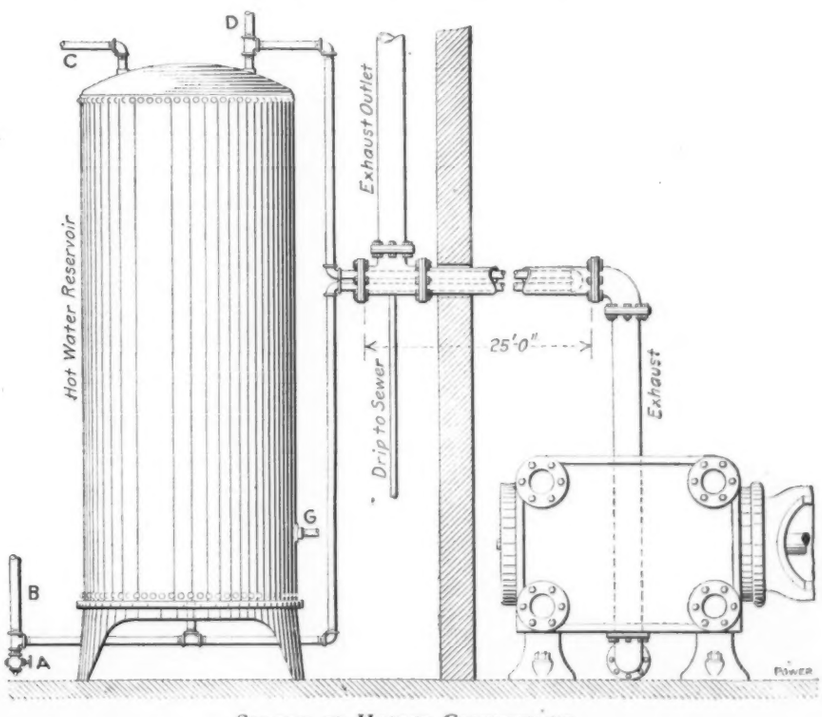


FIG. 3. HEATER AND TEMPERING STACKS

The flues of the fan system discharge in general about 10 feet above the floor of the room, and downward at an angle of about 15 degrees. Screens of plain lattice or diamond-design mesh are provided. Above the register faces are placed adjustable regulating dampers.

A recirculating flue connection is made to each intake chamber so that during the closed-down period of the factory the building is heated by recirculated air. An additional advantage of this arrangement is that it permits rapid heating of the building during the early morning hours by a rapid circulation of the recirculated air.



SKETCH OF HEATER CONNECTIONS

LETTER

A Homemade Water Heater

In an institution in this country where the management could not be persuaded to install a steam feed-water heater, although a large quantity of water was required for cooking and bathing, the engineer received permission to get the necessary supplies and install the arrangement shown.

The exhaust pipe from the engine is 5 inches in diameter and exhausts to the atmosphere. A coil 25 feet long was connected, as shown, to a 250-gallon range boiler. The outlet *D* is connected to the different taps and fixtures in the kitchens and bath and wash rooms. The cold-water inlet is located at *G*. A jacketed tank heater is connected at *B* and *C* and *A* is a drawoff cock.

When the connections were all made it was found that the fire for the tank heater could be dispensed with so long as the engine was running. This meant a saving in fuel of about one ton per week. The total cost for material to do the job was less than $5. Of course, it must be understood that the range boiler and tank heater were already installed, the only cost being for the coil and the connections to the reservoir.

JAMES E. NOBLE.

Toronto, Can.

Westinghouse Marine Reduction Gear

Until recently, there have been but few attempts to construct gearing for the transmission of large powers at unusually high tooth speeds. The importance of a system of noiseless gearing to be interposed between a high-speed turbine and the screw shaft of a vessel involving the transmission of many thousands of horsepower, has made the attainment of this object an exceedingly attractive field of investigation.

The most serious problem confronting the designer of such a system of gearing has been the development of a mechanism to insure an elastic, uniformly distributed tooth pressure between gear and pinion to avoid the concentration of an excessive tooth pressure at any single point of the working face, which would result in rapid deterioration and ultimate destruction of the teeth.

Fig. 1 is a perspective view, partly in section, of the gear perfected by the Westinghouse company. The illustration shows one of the gears installed on the U. S. S. "Neptune." Each gear transmits approximately 4000 horsepower at a speed of 1250 revolutions per minute for the pinion shaft, and about 130 revolutions per minute for the low-speed or driven shaft. Naturally, double-helical gears are used on account of the quiet-running qualities of this type, and the fact that the opposing helices automatically balance the end thrust.

The low-speed gear shaft rests in bearings seated in the main casing, and up to this point the design is fairly conventional.

Underlying principle of design is the supporting of the pinion shaft in a frame which floats on oil, the pressure on the oil being automatically regulated with the load on the gear.

Use of gear extended to turbine-driven direct-current generators and to centrifugal pumps.

Hydraulically Supported Frame

The essential and distinctively novel feature of the design is the hydraulically supported frame which carries the pinion shaft and its bearings, and by virtue of which the pinion shaft is self-alining.

This method of suspending the pinion-bearing frame is said to insure perfect balancing of tooth pressures, and the fluid cushion interposed between the pinion shaft and the main casing of the gear silences in a large measure the noise usually associated with the operation of high-speed toothed gearing. After a considerable period of operation, the gear teeth take on an excellent polish and show no signs of pitting or other deterioration that usually accompanies hard and continuous service.

The action of the frame may be more easily understood by referring to Fig. 2, which is a diagrammatic section stripped of all mechanical detail that might be confusing, and which illustrates the simple elemental principles of the design. Fully elaborated detail sections are shown in Figs. 3 and 4, and the symbols used in the description refer to the same parts in all of the illustrations.

Referring to Fig. 2, *A* represents the frame carrying the bearings of the pinion shaft, *D* is a portion of the main casing, and *E* is a right strut or beam secured to the main casing by means of a series of steel columns which are shown in Figs. 1 and 3. It may be noted that *A* does not fit closely between the parallel faces of *D* and *E*, but has freedom for a slight upward and downward movement.

On the upper and lower surfaces of *A* are three circular pads bored out to form shallow cylinders in which are fitted short pistons *C*; 1 indicates a passage or port, which communicates with the three shallow cylinders on the lower side of the frame *A*, and 2 indicates a similar port communicating with the corresponding cylinders on the top side of *A*.

When the gear is working, the reaction on the pinion teeth will tend to force the frame *A* against the casing *D* or the beam *E*, depending on the direction of rotation. If the reaction on the pinion teeth tends to force the frame *A* downward against *D*, then if oil or other suitable fluid under sufficient pressure be introduced at 1, it will be readily seen that the frame *A* will be lifted clear of the casing, and will actually float on the fluid in the cylinders. Similarly, if the direction of rotation be reversed so that the tendency is to force the frame *A* against the beam *E*, the introduction of fluid under pressure at 2 will prevent the frame *A* from coming in actual metallic contact with *E*. Since all three cylinders of the set that may be in action are connected to the same source of fluid supply, the slightest difference in tooth pressure on either side of the middle point of the pinion shaft *F* will cause the frame *A* to yield at the point where the pressure is unduly high. In thus yielding, the excess pressure is relieved and automatically transferred to the point in the working face of the pinion at which the tooth pressure was, on the instant, below normal.

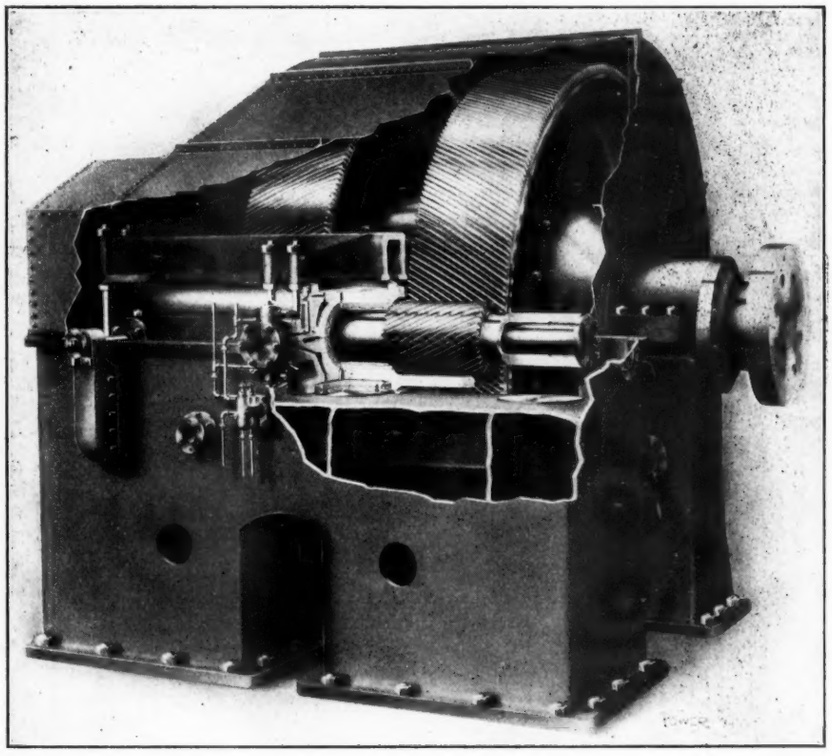


Fig. 1. Type of Gear Installed on U. S. S. "Neptune"

The broad underlying principle of the design is, therefore, the supporting of the pinion shaft in a frame which floats on oil, and which has no metallic or other rigid connection to the main casing. The practical application of this principle involves the accurate and automatic regulation of the fluid pressure in accordance with the load on the gear. The means by which this is accomplished will be understood from a study of the actual detail sections, Figs. 3 and 4. In Fig. 3 is shown a section through the floating frame at the middle bearing. The frame is split in a horizontal plane for convenience in removing or inserting the shaft and bearings. The longitudinal oil passages 1 and 2 communicate with the supporting cylinders, and the duct 6 conveys lubricating oil at low pressure throughout the length of the pinion frame and distributes it by means of side outlets to the bearings and to the pinions. An arm *B* projects into the valve box *G* and contains passages communicating with 1 and 2. A link *H* hinges the frame *A* to the casing *D* so that the slight vertical motion of the frame is multiplied at the end of the arm *B* which controls the oil valves.

For many years it has been known in a general way that if oil be fed to a rotating journal at the point of minimum pressure, it will be carried by the journal to the point of maximum pressure, and if a means of egress is provided the oil may be discharged against a pressure substantially equal to the maximum bearing pressure. Heretofore, practically nothing has been known regarding the quantity of oil which might be pumped through a properly designed bearing.

In the development of this gear, it was found that by suitably proportioning the bearings and supporting pistons the former could pump all of the oil required for floating the pinion frame.

Referring to the section through the bearing, as shown in Fig. 3, it may be seen that there are small passages connecting the top and bottom of the bearing with the upper and lower cylinders respectively. The bearings draw in oil from the lubricating system and discharge it through the check valves *L* into the supporting cylinders, and were it not for the automatic regulating mechanism in the valve box *G*, they would build up a pressure considerably greater than is required to keep the pinion-bearing frame floating in its normal position.

Fig. 4 is a cross-section on a larger scale through the valve box *G*. If the direction of rotation of the pinion is such as to bring the lower set of balancing cylinders in action, the excess pressure will tend to raise the arm *B* slightly, and as the ring valve *N* cannot follow it on account of coming up against a shoulder, the surplus oil will escape into the valve box.

Referring back to Fig. 3, *J* is a floating packing which prevents the overflow oil from spilling directly back into the main casing and compels it to run off through the drain pipe *K*. This pipe discharges into an open funnel, and the constant overflow of oil is an unfailing indication that the gear is functioning properly. From this funnel the oil may be returned to the main casing to be circulated again through the lubricating system.

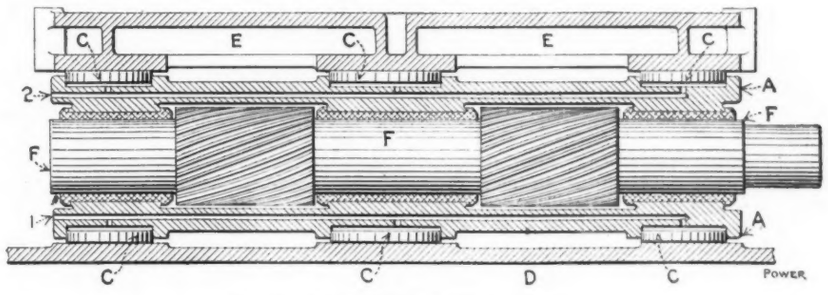


FIG. 2. ELEMENTAL SKETCH OF GEAR

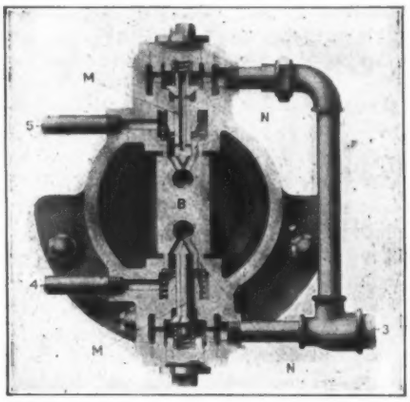


FIG. 4. ENLARGED SECTION THROUGH VALVE BOX

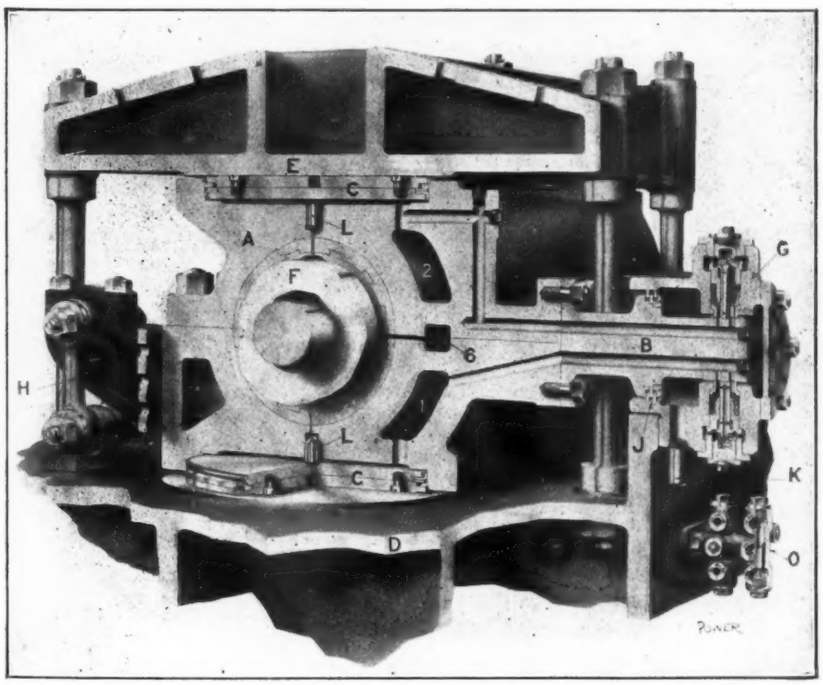


FIG. 3. SECTION THROUGH FLOATING FRAME AT MIDDLE BEARING

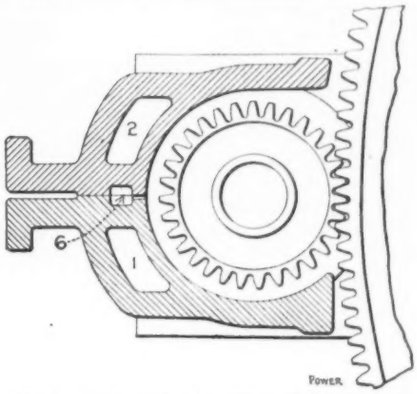


FIG. 5. SHOWING METHOD OF LUBRICATING GEAR TEETH

OIL FROM OUTSIDE PRESSURE SOURCE

When starting, it may be desirable, though not absolutely necessary, to sup-

ply the oil to the supporting cylinders from an outside-pressure source until the gear attains the normal speed, and the pumping action of the bearings is fully established.

In Fig. 4, oil from such an outside source of pressure may be introduced at 3 and led to the upper and lower valves as indicated. If the direction of rotation of the pinion is such as to depress the frame, the arm *B* depresses the ring valve *N* and the conical valve *M*, pushing the latter from its seat. The stem of the valve *M* is hollow, as shown in the section through the upper valve. When the valve *M* is opened the oil passes through the hollow stem, as is clearly shown, into the lower circular port in *B* and thence to the passage 1, Fig. 3, which connects with the lower set of cylinders, and is prevented by the check valves *L* from escaping into the bearings. When the balancing pressure has been attained, *B* rises to its neutral position, allowing *M* to seat and prevent further entrance of oil. If, by reason of a reduction of the load, the oil pressure in the supporting cylinders becomes excessive, *B* rises slightly above its neutral position, relieving the excess pressure in exactly the same way as when the oil is being pumped by the bearings. The total movement of *B* for adjusting over the entire range of load is only a few thousandths of an inch.

When the direction of rotation is reversed, the operation is just the same except that the necessary functions are performed by the upper valves instead of the lower ones.

From the foregoing description, it may be readily seen that the oil pressure in the supporting cylinders is always exactly in proportion to the torque that is being transmitted. By virtue of this fact, a simple pressure gage connected inside of the valve *M* will, if the speed in revolutions per minute be known, indicate the instantaneous load on the gear, so that the gear thus arranged is not only an efficient transmission device but a most accurate and sensitive dynamometer as well.

The connections to the pressure gages are indicated at 4 and 5, Fig. 4. If recording gages are used instead of simple indicating gages, and a graphic speed recorder is connected to the gear, the charts from these instruments would constitute a continuous log of the power transmitted.

Location of Pressure Gages

The pressure gages may be located in any convenient position and as far away from the gear itself as may be desired. The direction of rotation is always evident from an observation of which of the two gages is indicating pressure at the time.

If the gages were placed at any considerable hight above the gear, their indications would have to be corrected for the hydrostatic head of the oil column. Furthermore, if the gages were located at a great distance from the gear, there might be some annoyance from leakage, solidification or air pockets in the oil piping. For long-distance indications, an ingenious little device has been worked out which translates the oil pressure to a compressed-air supply, thence to be conducted to the pressure gages wherever they may be located. This translating device is indicated by *O*, Fig. 3.

Lubrication of Gear Teeth

Fig. 5, a section through the floating frame and pinion, illustrates the simple way in which the lubrication of the gear teeth is accomplished. The frame incloses the pinion except for a portion of the circumference where the teeth engage with those of the large gear. From the passage 6, lubricating oil passes to the pocket in which the pinion is located. The shape of this pocket is such that the oil cannot run out, but must be picked up by the teeth of the pinion. The oil when picked up is thrown off again by centrifugal force, but owing to the construction of the frame, it can escape only by being discharged directly into the teeth of the large gears just at the point of engagement.

In Fig. 1, at the left of the casing, is shown a bracket through the upper end of which is a screw-adjusted strut bearing against the pinion frame. A similar bracket and strut—not shown in the illustration—are located at the other end of the casing. These struts are for adjusting and maintaining constant the depth of engagement of the gear teeth. They do not interfere with the movement of the pinion frame in a vertical plane.

To obtain a flexible drive between the turbine and the gear, and at the same time to keep this gear in close proximity to the turbine, the pinion shaft is made hollow, and the driving shaft passes freely through this bore and is connected to the pinion shaft at the end furthest away from the turbine. This is an old and fairly well known construction which has been incorporated on account of its making the apparatus more compact and not that any novelty is claimed for it.

Adaptability

While the Westinghouse reduction gear was originally designed for marine propulsion, in order to harmonize the high speed which is the essential characteristic of an efficient steam turbine, with the comparatively moderate limiting speed for an efficient propeller, its adaptability for other purposes is opening up a field even broader than the one primarily contemplated.

The design of direct-current dynamos of fairly large capacities to operate at the high rotative speeds necessary for direct connection to efficient steam turbines has always presented difficulties that were seemingly unsurmountable. These difficulties have been eliminated by interposing the reduction gear between the turbine and the dynamo, so that each element of the combination may operate at the speed for which it is best adapted.

Similarly, centrifugal pumps for large capacities at moderate heads are not at all suitable for direct turbine drive, but turbine and pump may be connected through the reduction gear, constituting a highly efficient and attractive unit.

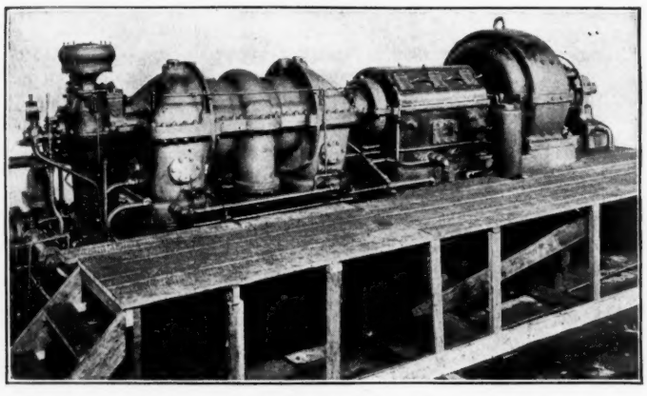


Fig. 6. Gear Used between Turbine and Direct-current Generator

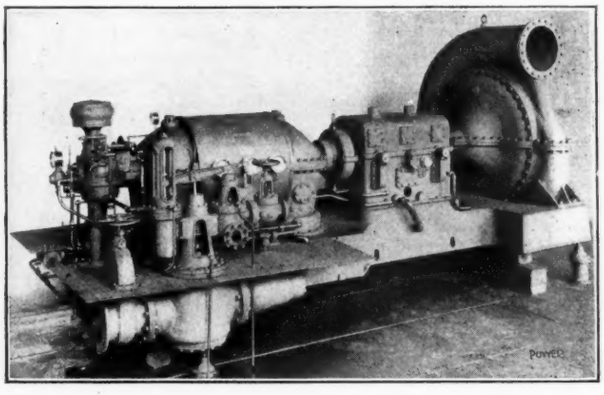


Fig. 7. Gear Used in Driving Centrifugal Pump

Naturally, for this sort of service in which the direction of rotation is never reversed, only one set of balancing cylinders and regulating valves is required.

Figs. 6 and 7 illustrate applications to direct-current generators and centrifugal pumps. These are only two out of a large number of new opportunities for the steam turbine which will present themselves as soon as it is realized that the handicap of inherent high rotative speed can be removed by a thoroughly reliable and durable system of gearing having an efficiency of over 98½ per cent., and that such a system is now an accomplished fact.

In addition to the two 4000-horsepower gears installed on the U. S. S. "Neptune," twelve 1000-horsepower and 2000-horsepower sets have been sold for driving direct-current generators and for other purposes. A number of these have already been in service for some months, running at speeds as high as 3600 revolutions per minute, with results that are reported to be gratifying in every particular.

Failure of Scotch Marine Boiler

At 7:30 a.m. on the morning of October 30, a failure occurred in the combustion chamber of a Scotch marine boiler at the plant of the Mount Clemens Sugar Company, Mount Clemens, Mich.

The boiler which failed was one of a battery of eight which were installed in 1901 and were used for a period of only three or four months each year during the beet-sugar season. It was 11 feet in diameter, 13½ feet long, with triple-riveted butt joints along the longitudinal seam. The shell plate was $\frac{13}{16}$ inch thick and the rear combustion-chamber sheet $\frac{15}{16}$ inch. Supporting the latter sheet were one hundred and seventy-two 1⅛-inch staybolts pitched 7¼x7¼ inches. The heads and tube sheets were ⅝ inch thick.

An inspection after the accident disclosed the fact that the staybolts between the rear head and the rear sheet of the combustion chamber stripped and the pressure hurled the latter sheet against the front part of the combustion chamber and forced it forward in some places 9 inches. The discharge of steam and water tore off the tube cap, furnace doors and the hoppers from the Jones stokers. These missiles were hurled through a window, 20 feet in front of the boiler, and a brick wall on the outside was demolished. Two men were dangerously injured from flying débris and a third who was covering another of the boilers was so badly scalded that he afterward died.

The initial failure seems to have occurred at the second horizontal row of stays from the top. The position of the crown bars shows that the rear sheet of the combustion chamber folded under the crown sheet. The stayed surfaces were clean and it is hard to account for their bulging.

The boiler was connected to a common main with the other boilers, the safety valves being set at 105 pounds. Calculations showed that it would require about 260 pounds per square inch to strain the stay sheet to its elastic limit and about 500 pounds per square inch to strain the staybolts to their elastic limit. Therefore it seems that the cause of the failure must have been other than direct pressure.

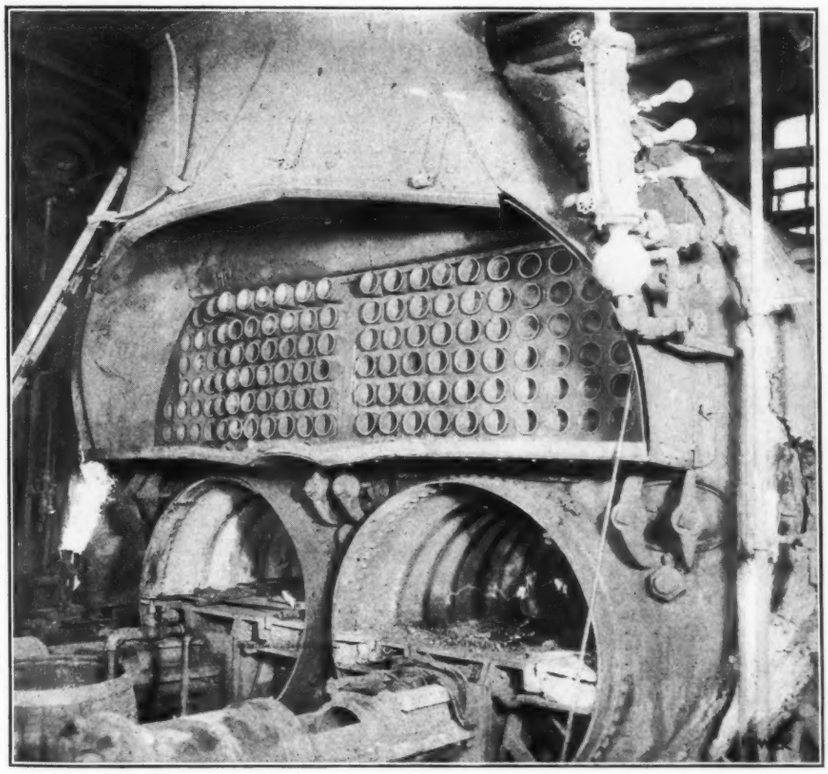


FIG. 1. FRONT OF BOILER, SHOWING PROJECTING TUBES AND FURNACE DOORS BLOWN OFF

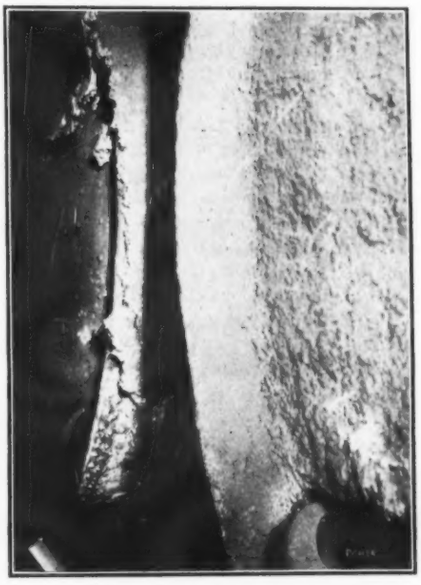


FIG. 2. SHOWING BULGED REAR HEAD

FIG. 3. REAR SHEET OF COMBUSTION CHAMBER

New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

The Lanza Continuous Diagram Attachment for Steam Engine Indicators

In the continuous indicator the problem is to move the paper forward without distorting the diagram. The movement of the paper must be proportional to that of the piston, and any extraneous movement is liable to distort the diagram in its outline or area. In some instruments the drum is given the additional forward movement while the pencil is drawing the usually straight back-pressure line. In another case diagrams are taken for alternate revolutions only, the paper being advanced during the intervening revolution. Both of these methods give a series of complete diagrams overlapping each other.

Prof. Gaetano Lanza, of the Massachusetts Institute of Technology, has adopted the method of making the paper move continuously in the same direction, and always proportionally to the piston movement.

In the guide extending to the right in Fig. 1 is a crosshead which is attached to the crosshead of the engine through a suitable reducing motion, and with a rigid connection instead of by the usual cord, as no spring is depended upon for the return stroke, and the crosshead must be pushed back. This elimiates any distortion from cord stretch or overtravel due to momentum, and gives, if the reducing motion is correct, a travel to the miniature crosshead exactly proportional to that of the crosshead of the engine. The movement of this miniature crosshead is communicated by means of the cord attached to it and running over the pulley at the extreme right, to clutches below the paper barrel of the instrument, and these are connected in such a way that the paper barrel will be revolved always from right to left, whichever clutch is working upon it; that is, in whichever direction the crosshead may be traveling.

The result is the production of diagrams like those shown in Figs. 2 and 3. Fig. 2 represents four revolutions of a steam engine with varying cut-off, and Fig. 3 a complete cycle from a gas engine firing and missing alternately. In the steam-engine diagram the pencil traces the line *A B C*, as upon the ordinary card, but the motion of the paper instead of reversing when the direction of the piston reverses at *C*, keeps on in the same direction, drawing the line *C D E*, which, being placed below *A B C*, as indicated by the dotted line, would produce the diagram for that revolution as ordinarily taken. In the gas-engine diagram the suction and compression lines are more distinct when each is shown by itself than it would be if superimposed, as shown by the dotted lines, upon one card. The variations of the several lines and points of the diagram can be readily studied, and the mean effective pressure measured either with an ordinary planimeter, or with an elongated planimeter or integrator by using the atmospheric or any other horizontal line as a base. With the integrator if the negative areas are traced anti-clockwise, the reading will be the effective area. With the ordinary planimeter, the positive and negative areas may be measured separately and their algebraic sum used.

The atmospheric line is put in by a separate pencil point, seen in the reproduced photograph at the left of the regular pencil. It is adjustable by the nurled head, projecting above the top of the paper drum. Still another pencil point, shown just below that which traces the diagram, makes the short vertical marks at *R, S, T,* etc., which indicate the end of the stroke. This pencil is brought into contact with the paper and given a short vertical motion by the contact of the small crosshead with the blocks shown on the upper guide, the position of which blocks is adjustable by means of the small gears shown between them. The paper rolls are arranged so as to maintain the requisite tension on the paper, however fast it runs, or however the relative sizes of the delivering and receiving spools may vary. The roll is slipped upon the spindle by lifting the keeper shown, and as much of the paper as has been used at any time can be removed from the receiving spindle, and the free end of the unused portion brought around to commence the taking of another series of diagrams. In the later model the keeper on the top of the first spool is replaced by a flat removable plate.

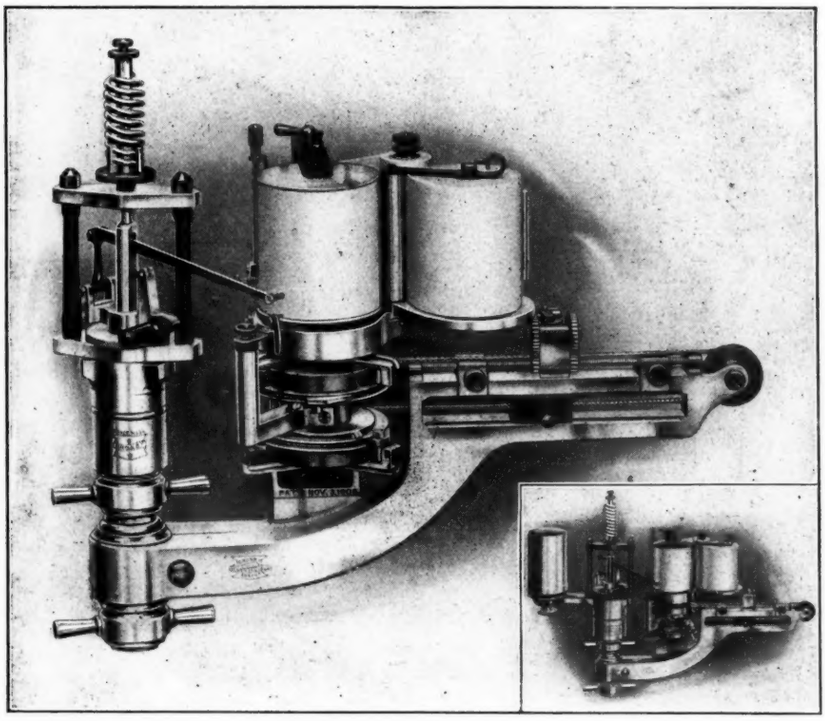


FIG. 1. VIEWS OF INDICATOR, SHOWING LANZA CONTINUOUS DIAGRAM ATTACHMENT

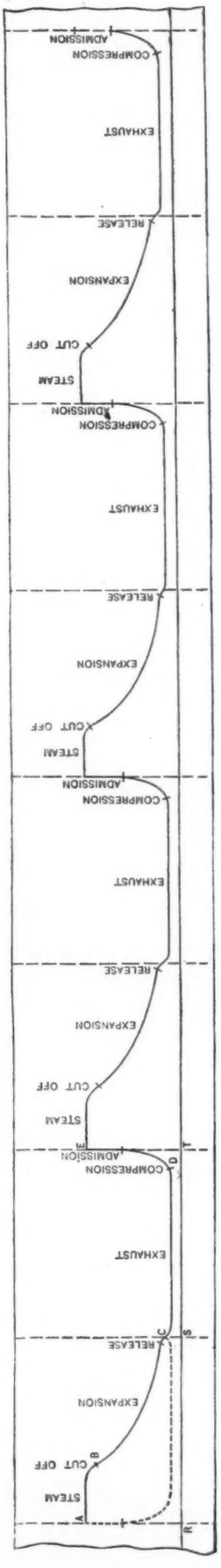


FIG. 2. PORTION OF CONTINUOUS DIAGRAM, SHOWING FOUR SUCCESSIVE REVOLUTIONS OF A STEAM ENGINE WITH A VARYING CUTOFF

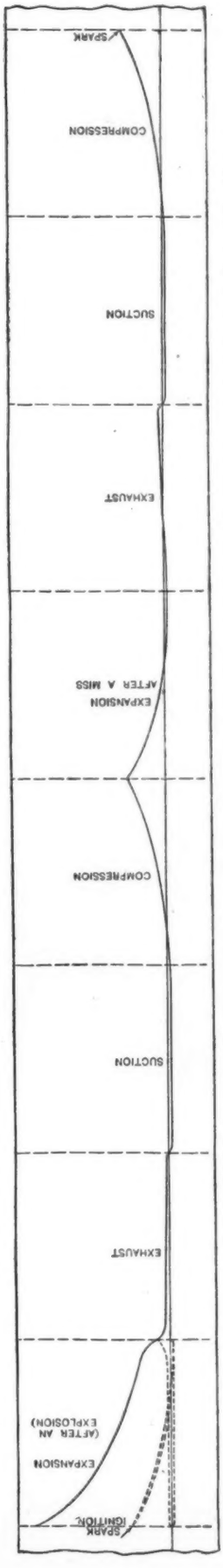


FIG. 3. PORTION OF CONTINUOUS DIAGRAM, SHOWING ONE COMPLETE CYCLE OF OPERATIONS OF A GAS ENGINE, WITH A CYCLE, FIRE ONE, MISS ONE

In the large engraving the indicator is shown as a complete instrument, but the continuous-diagram apparatus is ordinarily made as an attachment to a regular indicator, in the same way as the reducing motion. This can be clamped upon any indicator, as shown in the small panel, without removing the ordinary paper drum or otherwise taking the instrument apart. It is made by the Crosby Steam Gage and Valve Company, 38 Central street, Boston, Mass.

Composition Valve Disk

A new composition valve disk is being offered to the trade by the Ohio Injector Company, Wadsworth, O.

It is dark red in color. The manufacturer guarantees that it will not become brittle and break and that it will last until worn through. The disk can be used with most makes of valves using composition disks.

Duff Ball Bearing Jack

Among the late developments in lifting jacks is an improved ball-bearing journal jack recently placed upon the market by the Duff Manufacturing Company, Pittsburg, Penn.

This jack facilitates the rapid and convenient lifting of weights and is especially adapted where a short, light and powerful jack is required. It is said to be the only inexpensive ball-bearing jack providing a positive stop which absolutely prevents raising the lifting bar out of the jack.

DUFF BALL-BEARING JACK

An adjustable wheel-holding device has been designed to hold down the wheel when operating, but it may be easily detached when not required.

All gears are forged with machine-cut teeth and the jack is light in weight and is easily operated as the load is raised only on the downward and convenient stroke of the lever.

Boiler Tube Bursts

On Friday forenoon, November 10, one man was killed and three injured when a tube blew out in a boiler in Ellicott Square, the largest office building in Buffalo, N. Y. This is reported to be the third accident of a similar character that has occurred at this plant within a week. The first happened on the Saturday preceding and the second on Tuesday. In the latter case one man was slightly scalded. The repair of this boiler was just being completed when the tube in another boiler let go. One of the boilermakers conducting the repairs was killed and the other seriously scalded. The chief engineer of the plant and a boiler inspector who were in the room at the time were slightly injured by pieces of flying brick.

The boiler had been inspected only a week before and no defect of a serious character had been noticed. Further particulars, if any develop, will be given as soon as they are available.

Award of John Fritz Medal

At a dinner at the Waldorf-Astoria closing the annual meeting of the Society of Naval Architects and Marine Engineers, held in New York City on November 16 and 17, Sir William H. White, the British naval constructor, was presented with the John Fritz medal for 1911. The presentation speech was made by Onward Bates, of the American Society of Civil Engineers. The medal was awarded Sir William for notable achievements in the field of naval architecture.

News from the Institute

Colonel Goethals branch (Yazoo City, Miss.), of the Institute of Operating Engineers, started its regular bimonthly meetings the last part of September. The following papers were read at the meeting on October 14: "Safety Valve Calculations," by J. Chisholm, junior apprentice; "Safe Working Pressure of Boilers," by F. C. Holly, master operating engineer; "Boiler Horsepower," by W. G. Richardson, master operating engineer. In this branch it has been decided to conduct a full course in which papers will be presented covering the subject "The Boiler Room and Its Special Attachments," and all the problems connected therewith that an operating engineer should know. At each meeting the members are given a subject for discussion at the next meeting.

The New York branch held a meeting on October 20 and voted to name the branch after J. C. Jurgensen, the founder of the institute. In this branch it has been decided to give a course of lectures during the winter on power-plant accounting.

The new educational bulletin is now ready for distribution. It will give the announcement of special rates secured from the correspondence schools for students who wish to take up the institute work by the correspondence method.

Isometric Drawing Paper

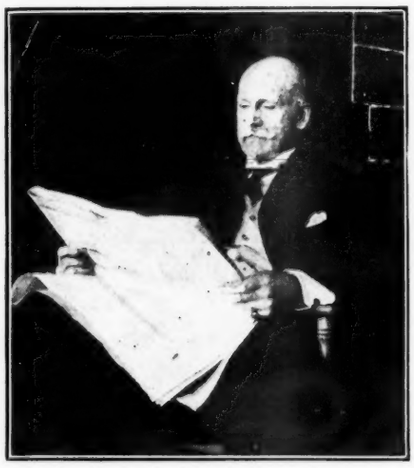
From the Norman W. Henley Publishing Company, 132 Nassau street, New York City, we have received a pad of isometric drawing paper, for the special use of engineers.

It is claimed for this paper that any knowledge of isometric projection is unnecessary, as its isometric ruling makes it easy to complete such a drawing without arduous study or calculation; any branch of mechanical drawing can use the paper to advantage.

The paper could be profitably employed by engineers who contribute to the technical papers and wish to illustrate their articles by drawings but are not equipped with all the necessary drawing implements. The lines are so ruled that but little difficulty will be had in plotting the figure desired.

OBITUARY

Henry W. Bulkley, the inventor of the first practical injector condenser, died on November 8 at his home in East Orange, N. J., of heart disease. Although 70 years



HENRY W. BULKLEY

of age, Mr. Bulkley always enjoyed good health until a week before his death.

Born in New York, in 1841, he received a common-school education and took a scientific course at the City College. When the Civil War broke out he enlisted in the Navy and served as a junior lieutenant in the engineering corps during the latter part of the war.

Mr. Bulkley started in the manufacturing line in the late sixties and in a few years invented his well known injector condenser. He continued the manufacture of the condenser up to the time of his death.

He was a member of the American Society of Mechanical Engineers, American Society of Mining Engineers and the American Society of Electrical Engineers. Mr. Bulkley is survived by a son, Henry D. Bulkley, who will carry on the business as formerly.

PERSONAL

O. D. Hogue has been appointed vice-president and treasurer of the Goulds Manufacturing Company, of Illinois.

W. H. Peterson, Portland, Ore., has been appointed chief engineer for the Court House building, Portland, by the board of county commissioners.

Charles E. Hague has been appointed Philadelphia representative of the Best Manufacturing Company, of Pittsburg, with headquarters at 1510 Land Title building. He is to have charge of the eastern Pennsylvania, Baltimore and Washington territory.

C. L. Stickney & Co. have been appointed the representatives of the Best company in the States of Washington and Oregon, with headquarters at 108 White building, Seattle, Wash.

SOCIETY NOTES

The Eighth International Congress of Applied Chemistry has invited the American Society of Refrigerating Engineers to take part in its proceedings on September 4, 1912, at Washington, D. C. The congress is to be held under the patronage of the President of the United States.

Partial announcement has been made of the program to be carried out at the annual meeting of the National Gas and Gasoline Engine Trades' Association, at the Hotel Hollenden, Cleveland, O., December 5 to 8 inclusive. The mornings of each day will be devoted to the exhibitors, as at previous conventions both exhibitors and engine manufacturers complained that not enough time was allowed for inspection of the accessories shown. Wednesday, the sixth, has been set aside as "engine manufacturers' day." This meeting will probably commence about 10 a.m., holding a session then and another in the afternoon. Aside from this there will be no programs for the mornings of any day, leaving these free for the inspection of such accessories as may be displayed. Tuesday afternoon will open the convention program, in the usual form, followed by reports of officers, announcements of committees, etc. Tuesday evening there will be an open meeting for power users under the auspices of the Cleveland Chamber of Commerce. Wednesday will be manufacturers' day. Thursday afternoon there will be a program of papers, as also on Friday afternoon. This being an annual meeting, there will be an election of three members of the executive committee on Wednesday evening, followed by the annual meeting of the executive committee on Thursday noon, for the selection of officers.

Moments with the Ad. Editor

A department for subscribers edited by the advertising service department of Power

"Broadway is a human churn," said a noted English writer who has been in this country and who sailed home a few days ago.

"I have seen," said he, "specimens of almost every nationality and every walk of life treading the pavement of Broadway between Fortieth and Forty-fourth streets. That is why I call this stretch of street the greatest thoroughfare in the world.

"That rush of humanity out there forces it on you that the whole game of life is a fight, that it is 'up to you,' as you Americans say, and that there's nothing but extinction for the man that's unfit."

This is American life, just as this writer says. In New York the lights and shadows of the battle probably reach their greatest intensity, and at certain hours of the day, on Broadway, all the different human atoms in the battle can be seen jostled or jammed together in one little area of sidewalk—the shop-girl, the beggar, the clubman, the country boy, the artist, the pasty-faced clerk, the razor-faced street gamin, and the tired, grimy workman going home.

Each individual in this whirlpool of men has some particular aim. Cutting out the ne'er-do-wells and the ones who live like bloodsuckers off the rest, each one is shoving ahead or holding his own, or trying to hold his own in the fight, on the basis of some particular job. Maybe it is a job identically like a thousand or a hundred thousand other jobs, or maybe there are only half a dozen others who can handle a job like it.

But, however that may be, every worker in the crowd is in some way or another doing this—

Selling himself to the rest.

The laborer is selling the muscles of his hands and legs; the artist, his brain, imagination and the skill of his fingers to those of the crowd who love beautiful things; the inventor, *his* brain—and so on.

The rank of each man in the crowd depends on two things—

What he has in himself to sell, and

How good a salesman he is.

For, after all, power to do a certain thing, no matter how well, doesn't count for much unless it is joined with the ability to find out what that thing is, where the market for it is, and then is joined with the ability to trade it off to good advantage and, once sold, to continually *show* that power to good advantage.

Therefore, another thing is true:

Being a good self-salesman is being a *self-advertiser*.

We don't mean the kind that blab into everyone's ears what they have done, generally not having much but blab to blab. We mean by self-advertising the straightforwardness that lets it be known that a good result has been due to you, if it has been, or the nerve to let it be know that you *can* do a thing, when you know you can, and then the working every wire to get the chance to *show* that you can. In fact, every man who is doing any sort of work—whether he thinks he believes in advertising or not—is all the time applying the principles of advertising with relation to himself, unless he is anchored to his job or to financial solvency by inheritance.

When one looks into the faces of the Broadway crowd, or the crowd of any city street, one sees why it is some are going up and others down, and others are barely holding on in a losing fight. It's because there's such an intense call now for those not who can do jobs exactly as they always have been done, but who can do them *differently* from, *better* than they have been done. The routine worker is the loser. Lots of routine work must be performed, that is outwardly routine, but there's mighty little of it but that can be done in a new way and is waiting for the man to show how, if it has not already been shown. *Differently* from, *better* than—is the demand everywhere.

In the power-plant field there's a demand for men who by doing their jobs *differently* from, *better* than they have been done, can bring saving in time, labor, fuel bills, or increase in power. For such men there will be bigger rewards as time goes on.

When you study through the advertisements of appliances or material, in a power-plant paper, to get light on your own problems, you are—whether you know it or not—studying how to be a better *self-salesman*. You are reaching for some idea which you believe you have the ability to apply after you find it, and in that way *show* that ability to better advantage. You are writing your own self-advertising copy. And when you *find* and *apply* some product described in these advertisements, and so bring about higher efficiency in your department, you *publish* that advertisement.

Advertising—advertising—and again advertising! See to it YOU get your share of its benefits!

BUSINESS ITEMS

The Wheeler Condenser and Engineering Company, of Carteret, N. J., manufacturer of high-vacuum surface and jet condensers, centrifugal pumps, air pumps, cooling towers, etc., announces that George Franklin Pond has been appointed manager for its Philadelphia territory, with office in Commonwealth Trust building. Walter G. Stephan has been appointed manager for the Cleveland territory with offices at 1325 Citizens building, Cleveland, Ohio.

Due to the fast increasing business in Birmingham, Ala., the H. W. Johns-Manville Company has found it necessary to change the location of its office from 1220 Empire building to 606 Chamber of Commerce building. This office will continue under the management of W. H. Fleming, who is well and favorably known throughout this section of the country, having been connected with the New Orleans branch of this company for a considerable time.

The Westinghouse Electric and Manufacturing Company has recently received, as subcontractors, through the John W. Danforth Company, Buffalo, N. Y., a contract from the United States Navy Department for an additional electrical equipment for the central power plant at the Mare Island navy yard, in California. This equipment includes six induction motors with a double equipment of 142½ horsepower, both single- and double-speed motors for driving the circulating and condensing pumps in the power house. The contract also includes three 50-kilovolt-ampere transformers for reducing the voltage of the generators for the motors; one 20-kilowatt motor-driven exciter set, two 25-kilowatt turbo-generator exciter sets, one 19-panel station switchboard, and one distributing panel. The generating equipment for this station was purchased some time ago and includes one Westinghouse-Parsons 1000-kilowatt, 2200-volt turbo generator. The equipment is to comply with the specifications of the Bureau of Yards and Docks of the Navy Department.

The Economy elevator-guide lubricator, "The Lubricator That Lubricates," is the title of an attractive catalog just issued by the Peterson Engineering Company, lubrication engineers, Hudson Terminal building, New York City. The catalog describes a new method of lubricating elevator guides in which a thin strip of grease is applied exactly where the shoes bear on the rails and for every trip of the car. Several different types are described suitable for steel and wooden rails and also for counterweight guides. Interesting data are given of tests made on elevators equipped with the Economy lubricator. For instance, it is stated that in the One Hundred and Sixty-eighth street station of the New York subway the Economy lubricator reduced the grease consumption from 480 ounces to 30 ounces per month. An analysis of the cost of lubricating the elevators in the Washington monument, by means of the Economy lubricator is also included. Copies of this catalog may be had by addressing the manufacturer at the above address.

The American Ship Windlass Company, builders of the Taylor stoker and marine equipment, such as steering gears, ship windlasses, towing machines, winches, anchors, etc., has been located for over a half century in Providence, R. I., at Waterman and East River streets. This plant is now being abandoned and all the business of the American Ship Windlass Company is being removed to Philadelphia where the company already had a large plant. To accommodate the growing busines a large foundry has recently been erected in Philadelphia. This company was established 54 years ago by Frank S. and Joseph Manton, who had much to do with the invention of the ship windlass. From the manufacture of the ship windlass the company branched out and since has added its marine machinery, and in 1905 began the manufacture of the automatic stoker, invented by E. E. Taylor, of Boston. This stoker, which is of the underfeed type and an inclined fuel bed, is being extensively introduced into power plants requiring a large capacity in a small space, and in cases where it is necessary to burn soft coal without smoke.

ENGINEERS WANTED

Under this head are published, without charge, advertisements of actual vacancies in power plants for operating engineers and assistant engineers. For the guidance of applicants for advertised positions, the advertisements must contain particulars to show the class of service demanded and the wages paid. Employers who desire to advertise under this head are requested to write for a blank form of application.

BREWERY IN OHIO wants engineer, energetic and progressive, who knows thoroughly the De La Vergne ice-making system; plant, two tubular boilers, 300 horsepower; two Corliss engines, 150 horsepower; pumps and boiler house machinery; plant fair condition; 12-hour day; salary $100 month. Box 525, POWER.

CHIEF ENGINEER for power plant in college near Philadelphia, Penn.; three 75-kilowatt Harrisburg engines, 2300 volts, four 150 horsepower return tubular boilers; force, one fireman, day, two at night; all latest improvements, including shower bath for men; no work outside power house; $100 per month; rural. Box 533, POWER.

HELP WANTED

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

MILLWRIGHTS WANTED for new pulp mill in Quebec. "B. H. E.," POWER.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

AGENTS WANTED for first-class steam specialty in use throughout United States. Address C. S. Wood, 410 S. 15th St., Philadelphia, Penn.

THE VULCAN SOOT CLEANER offers an exceptional opportunity for power specialty salesmen. For further particulars address G. L. Simonds & Co., 802 Steinway Bldg., Chicago, Ill.

ONE ENGINEER in each town to represent us, your choice of any indicator outfit on the market as a free premium; give your home address and firm employed by. The Olson Mfg. Co., Manitowoc, Wis.

AGENTS WANTED—To sell lubricating oils, belts, hose, paint and varnish, for power machinery, to factories, mills, auto owners, stores, threshers; exclusive territory to right party; oil experience unnecessary. Manufacturers Oil & Grease Co., Cleveland, Ohio.

SITUATIONS WANTED

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

YOUNG MARRIED MAN, 27 years old, wishes position as engineer of power plant or shunting locomotive; 10 years' experience. Box 532, POWER.

GAS ENGINEER open for position, 10 years' experience with gas engines, electrical machinery, bituminous and wood burning gas producers, can take charge of any size plant, executive ability, fluent Spanish, ready to go anywhere. Box 522, POWER.

MISCELLANEOUS

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

PATENTS—C. L. Parker, Patent Attorney, ex-examiner Patent Office, 904 G St., Washington, D. C. Write for Inventor's Handbook.

DIESEL FUEL ENGINES and producers; constructional drawings and information can be supplied by thoroughly trained engineer. Apply Box 531, POWER.

NEW SUCTION PRODUCER for burning low-grade fuel, with open visible fire; simple and cheap to construct; numerous plants at work. For license apply Box 530, POWER.

EVERY ENGINEER should be posted regarding the new system of vacuum heating installed without payment of royalty; I have valuable information; write today. T. L. Reeder, 1417 W. Jackson Blvd., Chicago, Ill.

FOR SALE

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

FOR SALE—One single cylinder, 66 horsepower gas engine and producer; made by the Power and Mining Machinery Co. Avery Scale Co., North Milwaukee, Wis.

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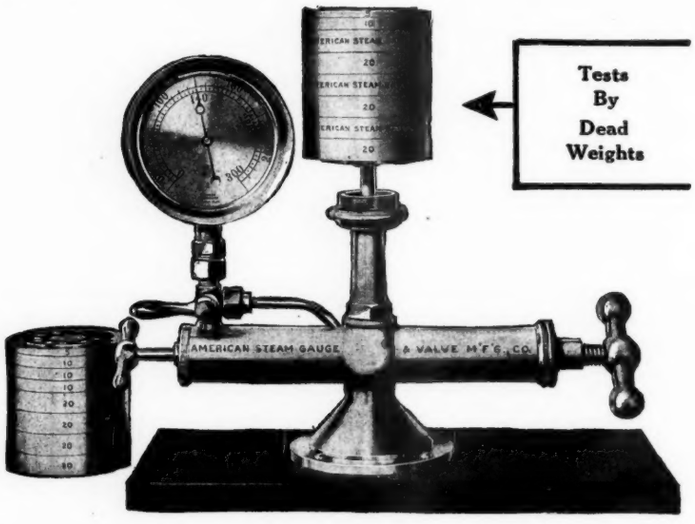

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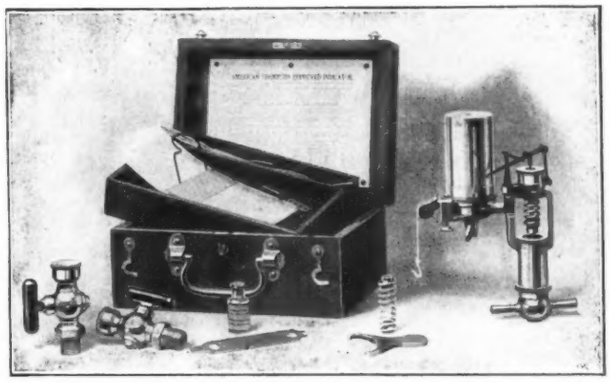

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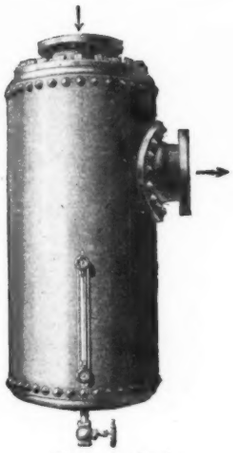


Cochrane Angle
Receiver Separator
Top Inlet, Side Outlet

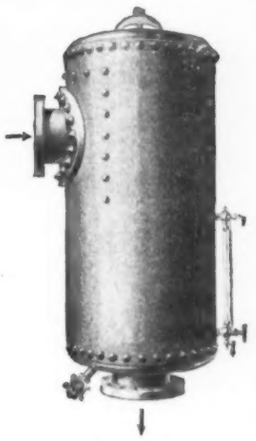
COCHRANE RECEIVER SEPARATORS MAKE SMALL STEAM PIPES MORE PROFITABLE THAN LARGE STEAM PIPES

By providing for the storage of a large amount of steam close to the throttle, the flow through the pipe line is equalized, and a smaller pipe will transmit the same amount of steam and give a higher average pressure in the steam chest.

1. Smaller steam lines not only cost less, but dissipate less heat.

2. Smaller steam pipes are cheaper, and the expense for valves and fittings is less.

3. Smaller steam lines are more flexible, and give less trouble than large pipe lines.



Cochrane Angle
Receiver Separator
Side Inlet, Bottom Outlet

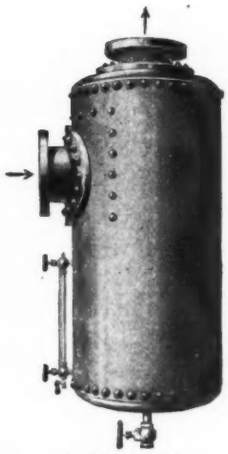
Cochrane Horizontal
Receiver Separator
Sizes 3 inches and upwards

THE COCHRANE RECEIVER SEPARATOR not only holds steam in reserve for the engine, but acts as a sump or well to receive flushes of water that may come over, due to priming of the boilers or condensation in pockets in the steam line. It may therefore save an expensive engine or turbine.

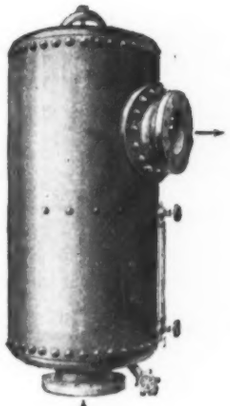
Cochrane Vertical
Receiver Separator
Sizes 3 inches and upwards

THE COCHRANE RECEIVER SEPARATOR removes from the steam the constant small percentage of moisture always found in steam as it leaves the boiler. This will pay good interest on the investment in the separator, by reason of the smaller amount of cylinder oil that may be used in reciprocating engines, and by reason of the higher economy and longer life of blades, secured with steam turbines.

If you would like to "post up" on this subject, send for our book on "*Recent Developments Affecting the Use of Separators in Connection with Live and Exhaust Steam Piping*", or submit details concerning any particular situation, and we shall be pleased to give you the benefit of our extensive experience in this work.



Cochrane Angle
Receiver Separator
Side Inlet, Top Outlet



Cochrane Angle
Receiver Separator
Bottom Inlet, Side Outlet

Harrison Safety Boiler Works

17th and Clearfield Sts., Philadelphia, Pa.